



**UPM**  
UNIVERSITI PUTRA MALAYSIA  
BERILMU BERBAKTI  
KAMPUS BINTULU SARAWAK



# E-PROCEEDING



**Green and Renewable Energy**

# GREEN

**International e-Conference** 2020

**18<sup>th</sup>-19<sup>th</sup> August 2020**  
**Webinar**

**"Current Status and Future  
of Renewable Energy"**

Organized by  
Universiti Putra Malaysia Bintulu Sarawak Campus

#UNSDG  
#UNSDGUPM  
#SDGUPM

4 QUALITY  
EDUCATION



**THE INTERNATIONAL E-CONFERENCE ON GREEN & RENEWABLE  
ENERGY 2020  
(GREEN 2020)**

18-19 August 2020

Universiti Putra Malaysia Bintulu Campus Sarawak (UPMKB)

*Published 2020*

Published by:

*Universiti Putra Malaysia Bintulu Sarawak Campus*

*P.O. Box 396, Nyabau Road,*

*97008 Bintulu, Sarawak, MALAYSIA*

URL Library UPM: <http://psasir.upm.edu.my/id/eprint/83485/>

URL UPM Bintulu: <http://green2020.upm.edu.my/>

The International e-Conference on Green and Renewable Energy (2020: Sarawak)

Perpustakaan Negara Malaysia

Cataloguing-in-Publication Data

International E-Conference on Green & Renewable Energy (2020: Sarawak) E-PROCEEDING: THE INTERNATIONAL E-CONFERENCE ON GREEN & RENEWABLE ENERGY 2020 (GREEN 2020), 18th-19th August 2020, Universiti Putra Malaysia Bintulu Campus Sarawak (UPMKB)/ Editors: Juniza Md Saad, Woon Wai Cheong, Omar Faruqi Marzuki, Mark Lee Wun Fui, Shafinah Kamarudin, Nurul Nadwa Zulkifli, Rosli Ismail, Nor Mariah Adam.

Mode of access: Internet

e-ISBN 978-967-12140-8-4

1. Clean energy--Congresses.
  2. Renewable energy sources--Congresses.
  3. Power resources--Congresses.
  4. Government publications--Malaysia.
  5. Electronic books.
  - I. Juniza Md Saad. II. Woon, Wai Cheong.
  - III. Omar Faruqi Marzuki. IV. Lee, Mark Wun Fui.
  - V. Shafinah Kamarudin. VI. Nurul Nadwa Zulkifli.
  - VII. Rosli Ismail. VIII. Nor Mariah Adam.
  - IX. Title.
- 333.794



---

*The view and concepts presented are those of the authors. No responsibility is assumed by the organizer for any injury and/or damage to persons or property as a matter of product's liability, due to negligence or otherwise, or from any use or operation of any methods, products, instructions, or ideas contained in the material herein.*

Universiti Putra Malaysia Bintulu Sarawak Campus, 2020

## FOREWORD BY CAMPUS DIRECTOR



Green and renewable energy are the significant attributes for Malaysia in reducing the global carbon emission to the environment. In-line with the United Nations Sustainable Development (SD) Goal no. 13 which highlights the needs of developing countries to both adapt to climate change and invest in low-carbon development, green and renewable energy not only promotes cleaner environment but also improves public health by reducing air and water pollution emitted by non-green energy resources.

This conference serves as a good platform for experienced as well as young researchers to share and explore related research work and innovations particularly in the field of green and renewable energy. The main focus of this conference is on four key areas of renewable energy, ranging from biomass, biogas and solid waste energy, solar and wind energy, hydro energy as well as alternative fuel (biodiesel and hydrogen). The well-diversified topics display that the theme of the conference **“Current Status and Future of Renewable Energy”** is very much reflected. The sharing session by keynote speakers renowned in their respective field, is yet another hallmark of this conference.

I would like to take this opportunity to congratulate the Organising Committee of Green 2020 for their tremendous efforts in bring this international event to new heights. The fruitful engagement, debate and collaboration among the Government, NGOs, Industries, Universities and Research Institutes during the entire conference session is certainly an important element for promoting green and renewable energy both in Malaysia as well as in the international arena.

I wish you a very successful conference.

Thank you.

**Professor Dr Bujang B. K. Huat**  
**Campus Director**  
**Universiti Putra Malaysia Bintulu Sarawak Campus (UPMKB)**

## **FOREWORD OF CHIEF EDITOR**

**Dear Authors and esteemed readers,**

On the behalf of the organising committee, it gives me great pleasure to extend a warm welcome to all presenters and participants to the Green International Conference Webinar, August 18 - 19, 2020.

Due to the overwhelming response GREEN conference is extended to two days with presenters from England, Iraq, Japan, Nigeria, the Philippines, Singapore and our comrades from Peninsular Malaysia as well as Sabah and Sarawak; to spend two precious days on enlightening latest updates on green and renewable energy. Topics covered are Biomass and Solid Waste Energy, Solar and Wind Energy, Hydro and Tidal Energy, Alternative Fuel (Biodiesel and Hydrogen) and Policy and Social Needs.

The committee is also honoured to present four prominent keynote speakers namely Prof. Dato' Dr. Mohd Ali Hassan (Universiti Putra Malaysia) who speaks about current status and prospects of biomass, Mr. James Ung (CEO Sarawak Energy) who presents renewable hydropower- Catalyst for Growth, Dr. Ng Sing Muk (General Manager Research and Development Sarawak Energy) to share overview on renewables for distributed power solution and Prof. Ir. Dr. Nor Mariah Adam (Universiti Putra Malaysia) to share the potential of gas turbine using sheep fat biodiesel enhanced with plasmatron and fuel atomization using sonic waves atomiser.

We thank all authors and participants for their contributions.

**Professor Ir. Dr. Nor Mariah Adam**  
**Conference Chair**



## **FOREWORD BY EDITOR-IN-CHIEF**

### **Greetings!**

It is a great pleasure for me to welcome you to the e-Proceedings issue of The International e-Conference on Green & Renewable Energy 2020 (GREEN 2020). This issue mainly highlights the importance of renewable energy especially on the impacts towards a sustainable environment through reduction of the carbon footprint.



The e-conference was conducted for two days back to back between 18th and 19th August 2020 and was a resounding success, with a large number of submissions from different participants' from different backgrounds and expertise. Hence the selected submissions for this issue will hopefully shed new light upon the complexities of the five keys renewable energy facets; Biomass, biogas and solid waste energy, Solar and wind energy, Hydro and tidal energy, Alternative fuels (biodiesel and hydrogen) and Policy and social needs.

On behalf of the editorial board to which I eternally grateful, I congratulate all those who contributed to successfully completing this first edition of the e-Proceedings of The International e-Conference on Green & Renewable Energy 2020 (GREEN 2020) and I look forward to future intellectual contributions.

Thank you for your interest in reading the papers published here.

**Dr. Juniza Md Saad**  
**Editor-in-Chief**

## **ORGANISING COMMITTEE**

### **Advisor**

Professor Dr. Bujang B. K. Huat

### **Chairman**

Professor Ir. Dr. Nor Mariah Adam

### **Bursar**

Dr. Wong Tze Jin

### **Secretary**

Dr. Nurul Nadwa Zulkifli

Mrs. Zahora Ismail

### **Head of Scientific and Technical:**

Biomass and Solid Waste	:	Dr. Nozieana Binti Khairuddin
Solar and Wind	:	Prof. Ir. Dr. Nor Mariah Adam Dr. Ellie Teo Yi Lih
Hydro and Tidal	:	Dr. Ellie Teo Yi Lih
	:	Assoc. Prof. Dr. Azmin Shakrine Mohd Rafie (Faculty of Engineering, UPM Serdang)
Alternative fuel	:	Dr. Sivasangar Seenivasagam
Policy and Social Needs	:	Dr. Ribka Alan

### **Secretariat:**

Dr. Omar Faruqi Bin Marzuki

Dr. Mark Lee Wun Fui

Dr. Shafinah Binti Kamarudin

Dr. Wan Nor Zanariah Binti Zainol@Abdulah

Dr. Wong Sie Chuong

Mr. Woon Wai Cheong

### **Publication:**

Dr. Rosli Ismail

Mohd Izhwan Muhamad (Faculty of Engineering, UPM Serdang)

### **Session Chairperson:**

Dr. Ellie Teo Yi Lih

Dr. Wan Nor Zanariah Binti Zainol@Abdulah

Dr. Shafinah Binti Kamarudin

Prof. Ir. Dr. Nor Mariah Adam

### **Protocol:**

Assoc. Prof. Dr. Yiu Pang Hung

Dr. Ellie Teo Yi Lih

Dr. Tengku Sharifah Marliza Binti Tengku Azmi

Dr. Faridah Abd. Razak

Dr. Mohamad Maulana Bin Magiman

Dr. Fatin Hana Binti Naning@Zin

Dr. Juniza Md Saad  
Mrs. Azira Sanusi

**Publicity, Media & Technical:**

Mr. Abdul Mohamad Bin Omar  
Mrs. Siti Rajanah Binti Abdul Aziz  
Mr. Zulkernain Bin Zamawi  
Mr. Roslan Binti Ismail  
Puan Dawiyah Binti Abri  
Mr. Benedict Anak Miden  
Mr. Fazdlizan Bin Yaakop

**Accommodation, Venue, Logistic and Decoration:**

Dr. Nor Hanifawati Binti Inai  
Dr. Koo Lee Feng  
Mr. Mohammad Saufi Bin Mohammad Ramli  
Mr. Mohd. Shahrul Nizam Bin Ab. Jabar  
Ms. Umi Kalthum Binti Abu Bakar  
Ms. Sakinah Binti Bujang  
Mr. Mohd. Zulkipli Saali  
Mr. Zulfikaruddin Saali  
Mrs. Gwendoline Ak Nelson  
Mrs. Daisy Pawie

## Table of Contents

**Biodiesel Production from Crude Karanja Oil using Heterogenous Catalyst from Seashells**

*A.A. Saleh, H. Dewi and H. Sinin* (pp. 1 - 11)

**An Affordable Calibrated Hot Box-Heat Flow Meter Suitable for Thermal Performance Measurement of an Insulation Panel**

*Hasila Jarimi and Yixin Wang* (pp. 12 - 20)

**Preliminary Experimental Study of Passive Solar Air Heating System in Drying Chilli under Malaysian Climates**

*Abdalla Abdur Rahman Shahbal and Khai Mun Ng* (pp. 21 - 30)

**Propect Evaluation of a Wind Farm Project for a Smart Campus in the Federal University of Kashere, Gombe State**

*Michael C. Ohakwere-Eze, Righteous Ombu, Udo A. A. and Mela S. Shimo* (pp. 31 - 40)

**Mechanical and Morphological Properties of Different Natural Fiber Reinforced Polylactic Acid Composites: A Review**

*S.F.K. Sherwani, S.M. Sapuan, Z. Ieman, E.S. Zainuddin and A. Khalina* (pp. 41 - 47)

**A Review on Green Cleaning During and Post Covid-19 Pandemic**

*A. Kamaruddin, N.N Zainol and M. A. Sulaiman* (pp. 48 - 58)

**Experimental Estimation of Water Velocity in a Selected Unregulated River (River Dindima) for Micro-hydrokinetic Potential**

*Michael C. Ohakwere-Eze, Righteous Ombu, James Audu, James Emmanuel and Henry I. Ikeri* (pp. 59 - 67)

**The Impact of Green Spaces on Residential Property Values in Malaysia**

*M.A Sulaiman, N.H Hashim, N.N Zainol, M.N Alias and W.Z Wan Yusoff* (pp. 68 - 77)

**Theoretical Framework and Future Directions of Green Human Resource Management on Employee Engagement**

*A. Vinothini* (pp. 78 - 92)

**Does Environmental Knowledge Moderate the Relationship Between Household Determinants' Intention to Practise Solid Waste Segregation-at-source? A Conceptual Paper**

*K.W. Cheng, S. Osman, Z.M. Jusoh and J.L. Lau* (pp. 93 - 104)



## BIODIESEL PRODUCTION FROM CRUDE KARANJA OIL USING HETEROGENOUS CATALYST FROM SEASHELLS

A.A. Saleh<sup>1</sup>, H. Dewi<sup>1</sup> and H. Sinin<sup>1</sup>

<sup>1</sup>Department of Mechanical and Manufacturing Engineering, Universiti Malaysia Sarawak  
94300 Kota Samarahan, Sarawak, Malaysia.

\*Email: aasaleh@unimas.my

Phone: +6082583299; Fax: +6082583410

### ABSTRACT

Gradual depletion of the world's petroleum reserves and impact of environmental pollution caused by combustion of fossil fuel, the search for substantial alternative energy resources such as biodiesel has gained importance. Biodiesel is a green fuel derived from plant oils or animal fats and consisting of long-chain fatty acid esters. In this study active calcium oxide catalyst was synthesized from *Meretrix Lyrata* (*M.Lyrata*) following calcination-hydration-dehydration technique. The catalytic feasibility of synthesized CaO was investigated in production of Karanja methyl ester (KME) from crude Karanja oil (CKO). KME was synthesized through esterification using  $H_2SO_4$  followed by transesterification utilizing CaO in a two-step reaction process of CKO and methanol. The *M.Lyrata* shells were calcined at 900°C and the catalyst samples were characterized by using FTIR, SEM, PSA, and BET-BJH spectrographic techniques. A maximum FAME conversion of 97.3% was obtained at optimum reaction conditions include methanol to oil ratio of 12:1, catalyst concentration of 2% wt, reaction temperature of 58 °C and reaction time of 2 h. In comparative study with the commercial CaO, *M.Lyrata* showed a higher catalytic activity. The catalyst reusability experiments ascertain reusability of CaO up to four reuse cycles had shown good efficiency. The economic comparative study confirms that CaO derived from *M.Lyrata* can be used as an alternative and feasible catalyst for the biodiesel production. The KME fuel properties were comply according to EN-14214 biodiesel fuel standards.

**Keywords:** Seashells, heterogenous catalyst, transesterification, Karanja biodiesel, Spectroscopy.

### INTRODUCTION

Biodiesel, also known as fatty acid methyl ester (FAME) or fatty acid ethyl ester (FAEE) can be obtained from vegetable oils or animal fats [1]. The rapid depleting of fossil fuel, demand of engine fuels that has growing tremendously and unpredictable in the availability lead to be the crucial factor to explore on alternative renewable fuel sources that able to supplement fossil fuels[2]–[4]. In recent years, biodiesel had shown exciting potential and receiving worldwide attention where it is known as a substitute for petro-based diesel fuel. Biodiesel has been known for its sustainability, non-toxic, biodegradability, less gaseous pollutant emissions and easy usability as fuel to be used in conventional diesel engines without any major modifications as compared to petroleum diesel[5]. Production of biodiesel was over 5 billion gallons in 2010.

Transesterification is considered to be the most reliable method for biodiesel production using vegetable oil feedstocks [6]. There are several types of catalysts are used for biodiesel production via transesterification reaction such as homogenous catalyst, heterogeneous catalyst and certain enzymes [7]–[9]. Usually KOH or NaOH are frequently being used as base homogenous catalyst as the reaction rate is relatively fast [10], [11]. Unfortunately, the using of homogenous catalyst cause a high volume of wastewater discharged during the purification or washing step of biodiesel in order to remove the residual catalyst present. This will result in water contamination as well as increase the cost on water treatment plants. The used catalyst from the reaction are cannot be recovered and reutilized backed into the process. Severe problems might arise such as formation of soap during transesterification which is caused by the presence of large amount of FFA content in vegetable oil. This will cause decreasing in catalytic efficiency [12]–[14]. Contrary to homogenous catalyst, heterogeneous catalyst have a great number of benefits. For instance, utilization of heterogeneous catalyst easily separable from biodiesel product and recyclable. This lead to economical way for biodiesel production by reducing the consumption of wastewaters and can be reuse for next transesterification [15]. In the recent times, research studies on using calcium oxide (CaO) as a heterogeneous catalyst have been carried out owing to its low cost [16], [17] and high basicity [18]. Additionally, CaO is readily availability in nature, and can be derived from natural waste materials such seashell, rice husk, egg shell, mussel shell and chicken bones make the production of biodiesel more cost effective. Moreover, due to its low stability, non-toxic and high basic properties in biodiesel [19]–[21] CaO is a promising heterogeneous catalyst for biodiesel production. Present research focuses of synthesis of active CaO catalyst using locally available waste seashells as a raw material. An economically feasible laboratory scale synthesis technique, calcination-hydration-dehydration is adopted in CaO synthesis. Newly synthesized catalyst samples were characterized using FTIR, SEM, PSA, and BET-BJH spectrographic techniques. KME production was experimented with newly synthesized active CaO using two-step transesterification protocol. The biofuel properties are characterized according to EN 14214/ASTM biodiesel standards.

## METHODS AND MATERIALS

### Materials

The crude Karanja oil (CKO) was extracted from their seeds using soxhlet apparatus and mechanical expeller. According to Mahanta and Shrivastava, soxhlet apparatus yields better quality and amount of vegetable oils[22]. The experimental data revealed that acid value and saponification value for CKO as 5.06 mg KOH/mg and 187 mg KOH/mg respectively [23]. The laboratory grade chemicals that include methanol (MeOH; >99% pure),  $H_2SO_4$ (95-97%), distilled water, NaOH and calcium oxide (UNI-CHEM chemical reagents; CAS No. 1305-78-8; MW = 56.08) were used for experimental protocols. The biodiesel production was carried out at the Energy Laboratory in Faculty of Engineering, Universiti Malaysia Sarawak (UNIMAS) Sarawak, Malaysia.

### Catalyst Synthesis

Initially, the *M.Lyrata* shells were collected from a local market situated at Samarahan, Sarawak, Malaysia. The shells were then rinsed simultaneously using tap, hot and distilled water to remove any dirt and stain as well as impurities on the shells surface [24]. *M.Lyrata* shells were dried

overnight in a hot air oven at 105°C. The dried shells were then grinded to fine powder form using a commercial blender and sieved through 80µm mesh. The CaO derived from *M.Lyrata* was calcined at 900°C for 2 h in the muffle furnace (KSL-1700X-A4, MTI Corporation, USA) then the shell powder were refluxed in distilled water for 6 h at 60 °C. The samples were filtered and dried overnight at 120°C for 3 h as well as recalcined for 3 h at 600 °C to produce fine calcium oxide. The CaO samples were dried in a hot air oven at 100°C for 1 h and finally stored in air tight sample bottle [24]. Thus the CaO was successfully synthesized an active heterogeneous CaO catalyst synthesis from *M.Lyrata* by ‘calcination-hydration-dehydration’ technique.

### CaO Catalyst Characterization

The Chemical composition of *M.Lyrata* shells synthesized CaO was evaluated over the wavelength region of  $600\text{cm}^{-1}$  to  $4000\text{cm}^{-1}$  by employing FTIR: Fourier Transform Infrared Spectrophotometer (Perkin Elmer Model 100 series). SEM: scanning electron microscope (Hitachi TM3030) was utilized to study the particle morphologies and elemental analysis of both calcined CaO and commercial CaO. PSA: Particle size analyzer (CILAS-1090) was used to analyze particle size distribution of *M.Lyrata* shells synthesized catalyst. The surface area of calcined *M.Lyrata* seashell and commercial CaO were estimated using Brunauer-Emmett-Teller (BET) equation while pore diameter was determined using Barrett-Joyner-Halenda (BJH).

### Experimental Set up for Biodiesel Production

The free fatty acid (FFA) contents of CKO ranges over 20% which results in lowering biodiesel yield especially in transesterification of vegetable oils using heterogeneous solid catalyst [24][25]. Since the FFA of CKO higher than the required (>1%) KME that derived from CKO is achieved by a two-step process [25]. According to Ahmad et.al, transesterification process transforms crude oil to fatty acid methyl ester [26]. The KME was produced by performing pre-treatment (esterification) followed by alkaline (base catalyzed) transesterification. [6]. Esterification: At first CKO was heated up to 100°C for 30 min. to remove moisture then, acid pre-treatment process was applied to reduce the FFA content by using 0.8%  $\text{H}_2\text{SO}_4$  (v/v) added to oil then mixed with 6:1 (methanol to oil ratio) molar ratio. The solution was heated to 50 °C and stirred for 90 min. Subsequently, the solution was transferred to separating funnel which was allowed to settle for 2 h. The methyl ester was washed three times using distilled water and the layers of oil from methanol and  $\text{H}_2\text{SO}_4$  were separated. The pre-treated oil was heated up to 100°C to remove excess water content [26]–[31]. Transesterification: the second step of biodiesel production process. The pretreated CKO was mixed with methanol at a molar ratio of 12:1 and CaO catalyst concentration of 2 wt % at 60 °C. The reaction was then proceed with stirring at 250rpm for 2 h using magnetic stirrer. The reaction mixture was transferred to a separating funnel for separation of 2 layers where the upper layer consists of KME while the lower layer consists glycerol [32]

### Catalyst Reusability Study

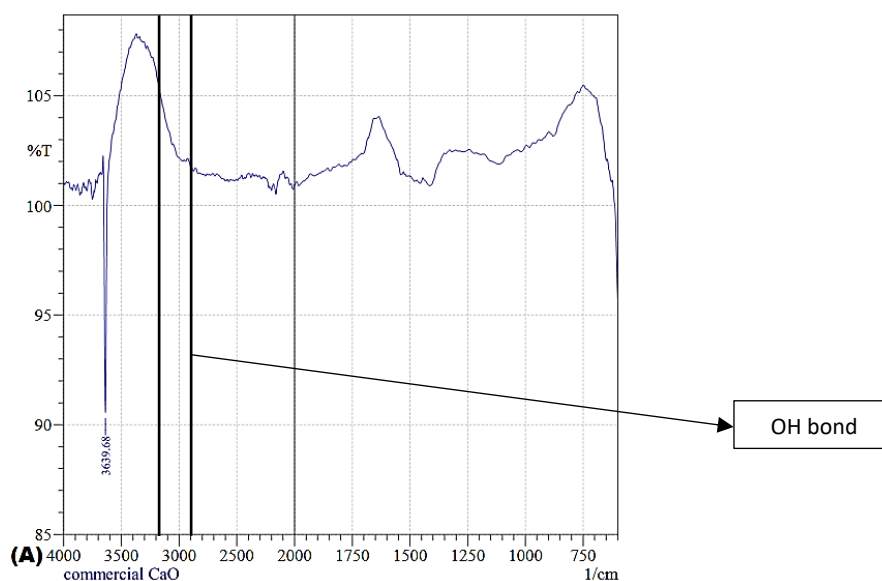
Karanja biodiesel and other mixtures were centrifuged at 3000rpm for 1hr to recover *M.Lyrata* shells CaO catalyst and then washed using n-hexane for three times to remove all dissolved impurities. The sample was then dried in an oven for 24h. Then, the recovered catalyst recalcined again before use for the next transesterification of CKO for 3h at 600 °C.

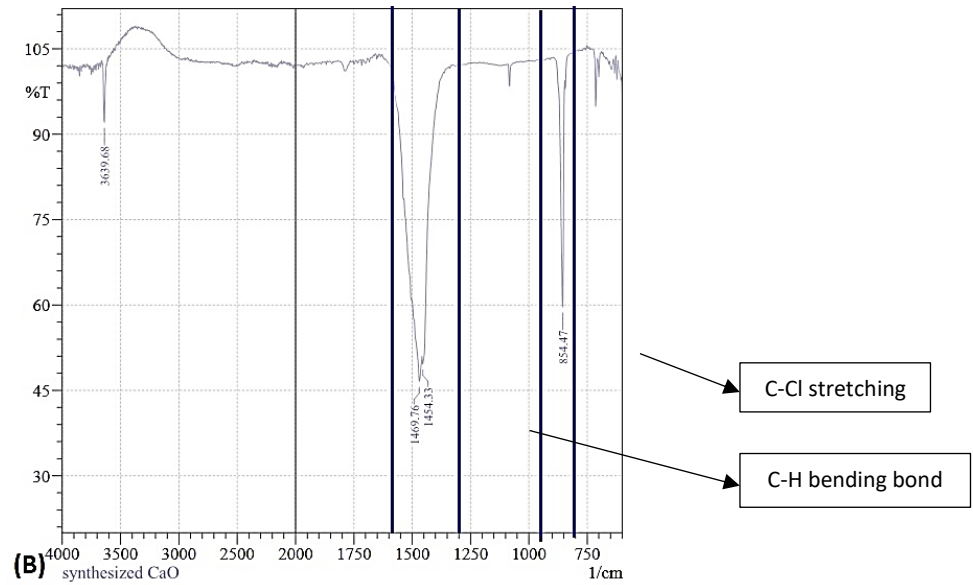
## RESULTS AND DISCUSSION

### Catalyst Characterization Analysis

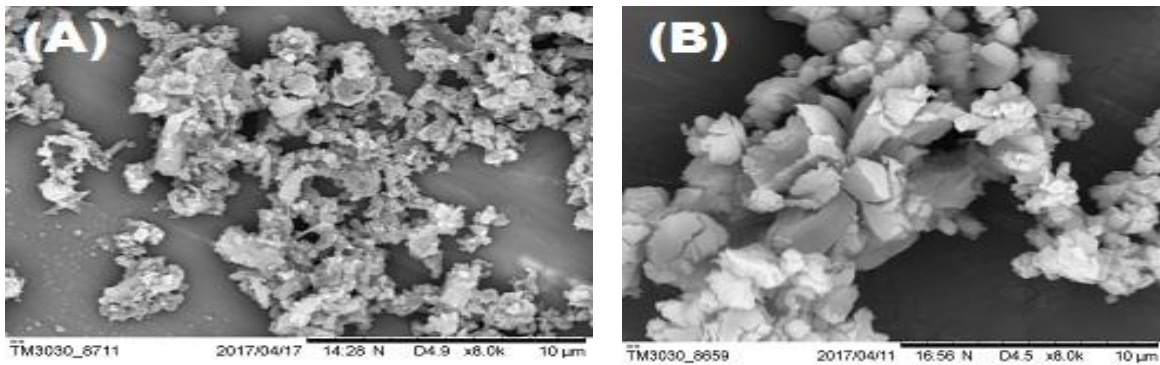
The infrared (IR) spectrum of CaO catalyst as synthesized from *M. Lyrata* shells was graphically shown in figure 1. It's evident that CaO group absorptions were strongly attributed less than  $700\text{ cm}^{-1}$  corresponds to the functional group Ca-O from calcium carbonate. The peak indicates the strong besides broad medium absorptions band signifies the Ca-O which confirmed the presence of CaO. The absorption peak over  $854.47\text{ cm}^{-1}$  corresponds to C-Cl stretching. The absorption band over wavelength  $1469.76\text{ cm}^{-1}$  and  $1454.33\text{ cm}^{-1}$  were corresponding to medium C-H bending bond. Further, a weak absorption wavelength more than  $3700\text{ cm}^{-1}$  specifically can be seen at  $3639.68\text{ cm}^{-1}$  where the absorption peaks correspond to hydroxyl group due to the presence of calcium hydroxide.

The surface morphology of calcium oxide derived from hard clam shell and commercial CaO was analyzed using scanning electron microscopy (SEM). Referring to figure 2(A), it can be observed clearly showing that SEM images of CaO derived from hard clam shell was totally different from the commercial CaO. SEM image of calcium oxide that synthesized from hard clam shell showed a porous structure with smaller particles. According to Buasri et al., the smaller the sizes of grains and aggregates of *M. Lyrata* CaO could give a higher specific surface area [13][14]. Conversely the commercial CaO particles in agglomerate forms.

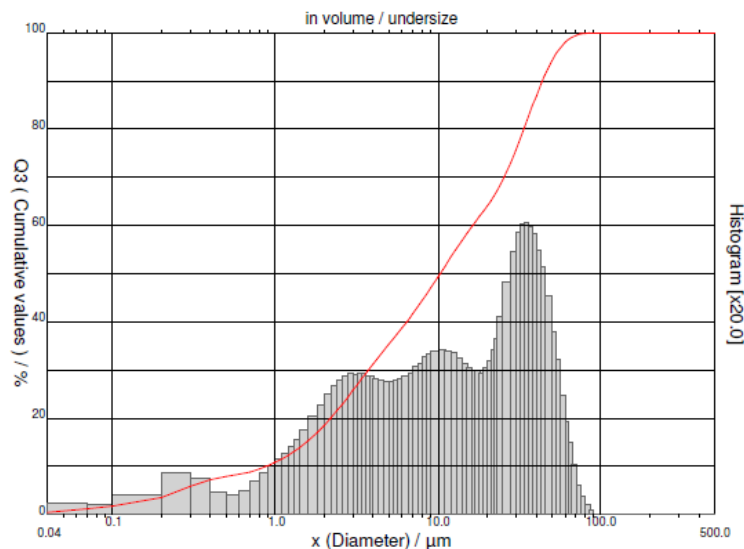




**Figure 1.** FTIR Spectrum of commercial CaO (A) and synthesized CaO from *M. Lyrata* (B)



**Figure 2.** SEM images of synthesized CaO (A) and commercial catalyst (B)



**Figure 3.** Particle Size Distribution of CaO synthesized from *M. Lyrata*

Figure 3 shows the particle size distribution of CaO particles from the hard clam shells where the particle distribution is in the range of 0.04 to 60  $\mu\text{m}$ . A large fraction of the powder particle falls within a range of 20–40  $\mu\text{m}$ . The average particle diameter was 15.67  $\mu\text{m}$ . The highest peak of

the bimodal size distribution ranges from 30-60  $\mu\text{m}$ . The BET and BJH analysis of *M. Lyrata* synthesized having a  $S_{\text{BET}}$  of  $36.6 \text{ m}^2/\text{g}$ , pore diameters of 13.861 nm and total pore volume of 0.126 cc/g respectively. Further, commercial CaO having a  $S_{\text{BET}}$  of  $5.21 \text{ m}^2/\text{g}$ , pore diameters of 11.355 nm and total pore volume of 0.0121 cc/g. According to Ren, Ma, Bruce, Knochel & Bein, the results  $S_{\text{BET}}$  of *M. Lyrata* is comparatively high and the pore diameter ranges is categorize within mesopores 2nm to 50nm consequently results in high surface area along with their catalytic activity, able to store energy and suitability of adsorption [33][34].

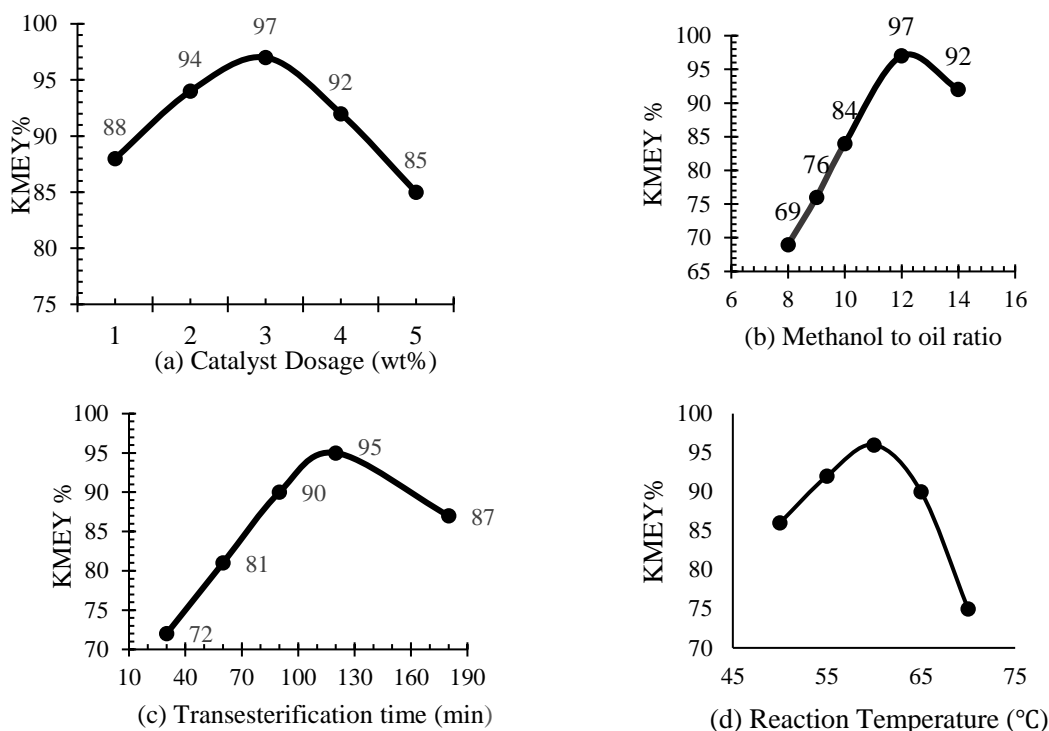
### Karanja Biodiesel Production Analysis

In the heterogenous transesterification, CKO was mixed with methanol and catalyzed by alkaline earth oxide; CaO. The influence of reaction time, reaction temperature, catalyst concentration and methanol ratio on performance of synthesized CaO under different transesterification conditions were investigated. Based on the results tabulated in table 1, the higher methyl ester yield for transesterification of using synthesized CaO catalyst is achieved at 97.3% in the presence of 2 (wt %) CaO when the methanol to oil ratio of 12:1 at 58 °C temperature within 2 h. Figure 4(a-d) presents optimal reaction parameters for KME production via. Two-step transesterification. The optimum of methanol to oil ratio was 12:1 over the catalyst in the present study, which was double the practical methanol to oil ratio for homogeneous transesterification of 6:1. This higher the amount methanol would cause the development of methoxy specified of the surface of CaO as well as the reaction equilibrium shifted to forward direction. However, KME yield will not increase when the methanol ratio is over 12. The reason for this is the glycerol eventually dissolved in excessive methanol and at the same time constrain the reaction of methanol to the reactants and catalyst. However, further increase in methanol/oil ratio up to 18 did not promote the reaction. It was considered that the glycerol would largely dissolve in excessive methanol and subsequently inhibited the reaction of methanol to the reactants and catalyst [34].

From the results, by comparing with the commercial CaO, hard clam showed a higher catalytic activity. Optimum conditions of this catalyst were achieved by giving a FAME conversion of 97.3% when the methanol to oil ratio of 12:1 in the presence of 2 (wt %) catalyst at 58 °C for 2 h of reaction time.

**Table 1.** Effect on various parameters on production of Karanja methyl ester yield (KMEY)

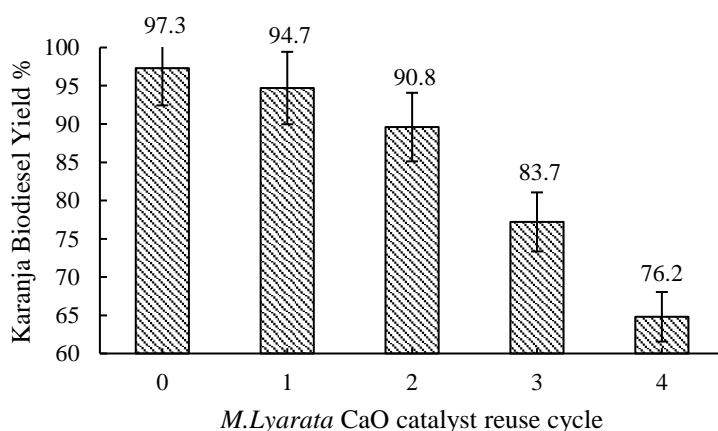
Catalyst loading (CL)		Methanol ratio (MR)		Transesterification time (TT)		Reaction temperature (RT)	
CD (wt %)	KMEY %	MR (mol.)	KMEY %	TT (min)	KMEY %	RT (°C)	KMEY %
1	78	8	69	60	81	50	86
2	94	10	83	90	90	55	92
3	97	12	97	120	95	60	96
4	90	14	92	180	87	65	90



**Figure 4 (a-d).** Optimization of KME yield via. Two-step transesterification

### *M. Lyrata* Synthesized CaO Reusability Analysis

The *M. Lyrata* catalyst reusability was studied by using optimal condition of transesterification at a molar ratio of 12:1 and catalyst concentration of 2 wt % at 58 °C for 2 h period of time. After reaction is finished, separation of catalyst from the mixture is being made and proceed to be used for second reaction under same conditions. From figure 5, it was observed that the catalyst active for 3 reaction cycles with yield above 90%. It is found out after 4th reaction cycles, the biodiesel yield lowers to 83.7%. The reasons for this is catalyst deterioration is occurred due to the change in surface structure causing losing of active sites in the synthesized catalyst. Moisture in the reactant cause the calcium oxide to transform into calcium hydroxide which deteriorate the catalyst activity. However, by recalcined the catalyst at 600°C could recover the activity [35][36].



**Figure 5.** *M. Lyrata* CaO catalyst recycle and reusability experimentation

## Properties of KME

### Properties of biodiesel

Table 2 and table 3 showed the analysis and the test methods adopted for the determination of CKO methyl esters properties.

**Table 2.** Properties of CKO before transesterification and test methods used

PROPERTIES	cko	EN 14214/ASTM STANDARD TEST METHODS
DENSITY, G/ML 15°C	0.924	EN ISO 3675
WATER CONTENT, %	10.20	EN ISO 12937
SAPONIFICATION NUMBER, MG/G	186.4	ASTM D5558
ACID NUMBER, MG KOH/G OIL	31.24	EN 14104
FFA, %	15.62	ASTM D5555
KINEMATIC VISCOSITY (40°C), mm <sup>2</sup> /s	27.82	EN ISO 3104

**Table 3.** Properties of KME and test methods used

PROPERTY	kme	LIMITS	EN 14214/ASTM STANDARD TEST METHODS
DENSITY (15°C), G cm <sup>-3</sup>	0.883	0.860-0.900	EN ISO 3675
POUR POINT, °C	3	NS <sup>a</sup>	ASTM D 97
WATER CONTENT, %	0.038	0.05% max	EN ISO 12937
ACID VALUE, KOH, mg g <sup>-1</sup>	0.17	0.5 max	EN 14104
KINEMATIC VISCOSITY (40°C), mm <sup>2</sup> /s	4.66 ± 0.02	3.50-5.00	EN ISO 3104
FLASH POINT, °C	212	120 min	EN22719
CLOUD POINT, °C	6	NS <sup>a</sup>	EN14214
FREE GLYCERIN, WT%	0.0064	0.02	ASTM D6584
TOTAL GLYCERIN WT%	0.082	0.240	ASTM D6584
MONOGLYCERIDE CONTENT, WT%	2.63	<0.8	EN4214
PHOSPHORUS, MG/KG	0.04	<4-10	ASTM D4951
TRIGLYCERIDE CONTENT, WT%	0.06	<0.2	EN4214
DIGLYCERIDE CONTENT, WT%	0.78	<0.2	EN4214
GROUP 1 METALS (NA + K), MG/KG	-	0.5	EN14214



## CONCLUSIONS

In this study, CaO catalyst was successfully synthesized from *M.Lyrata* seashells by following a calcination – hydration – dehydration technique. The characterization of CaO was carried out using FTIR, SEM, PSA, BET and BJH. The BET and BJH spectro photographic techniques. The characterization results revealed that the synthesized CaO catalyst had an  $S_{BET}$  of  $36.6 \text{ m}^2/\text{g}$ , pore diameters of 13.861 nm and total pore volume of 0.126 cc/g respectively. Under optimum transesterification reaction conditions of methanol to oil ratio of 12:1 in the presence of 2%wt catalyst at 58 °C for 2 h of reaction time, a KME yield of 97.3% was yielded. It was observed that the catalyst active for 3 reaction cycles with yield above 90%, The produced KME fuel properties were tested according to EN 14214 biodiesel standards.

## ACKNOWLEDGEMENTS

The authors would like to acknowledge Universiti Malaysia Sarawak (UNIMAS) for providing the technical and financial assistance during this work under the grant 02/SpFRGS/1538/2017.

## REFERENCES

- [1] S. B. Lee, J. D. Lee, and I. K. Hong, "Ultrasonic energy effect on vegetable oil based biodiesel synthetic process," *J. Ind. Eng. Chem.*, vol. 17, no. 1, pp. 138–143, 2011.
- [2] "U.S. energy consumption rose slightly in 2016 despite a significant decline in coal use - Today in Energy - U.S. Energy Information Administration (EIA)." [Online]. Available: <https://www.eia.gov/todayinenergy/detail.php?id=30652>. [Accessed: 06-Apr-2017].
- [3] H. X. Bai, X. Z. Shen, X. H. Liu, and S. Y. Liu, "Synthesis of porous CaO microsphere and its application in catalyzing transesterification reaction for biodiesel," *Trans. Nonferrous Met. Soc. China (English Ed.)*, vol. 19, no. SUPPL. 3, pp. 2–5, 2009.
- [4] "Krawczyk, T. (1996) Biodiesel—Alternative Fuel Makes Inroads But Hurdles Remain. INFORM, 7, 801-829. - References - Scientific Research Publish." [Online]. Available: [http://www.scirp.org/\(S\(351jmbntvnsjt1aadkposzje\)\)/reference/ReferencesPapers.aspx?ReferenceID=1631189](http://www.scirp.org/(S(351jmbntvnsjt1aadkposzje))/reference/ReferencesPapers.aspx?ReferenceID=1631189). [Accessed: 06-Apr-2017].
- [5] K. Watcharathamrongkul, "Calcium oxide based catalysts for ethanolysis of soybean oil," ... *J. Sci. ...*, vol. 32, no. 6, pp. 627–634, 2010.
- [6] F. Ma and M. A. Hanna, "Biodiesel production: A review," *Bioresour. Technol.*, vol. 70, no. 1, pp. 1–15, 1999.
- [7] A. K. Agarwal, V. Katiyar, and K. Singh, "Optimisation of Karanja/Jatropha-Methanol emulsification variables and their engine evaluation," *Renew. Energy*, vol. 96, pp. 433–441, 2016.
- [8] D. A. Torres-Rodríguez, I. C. Romero-Ibarra, I. A. Ibarra, and H. Pfeiffer, "Biodiesel production from soybean and Jatropha oils using cesium impregnated sodium zirconate as a heterogeneous base catalyst," *Renew. Energy*, vol. 93, pp. 323–331, 2016.
- [9] J. G. Duarte, K. Leone-Ignacio, J. A. C. da Silva, R. Fernandez-Lafuente, and D. M. G. Freire, "Rapid determination of the synthetic activity of lipases/esterases via transesterification and esterification zymography," *Fuel*, vol. 177, pp. 123–129, 2016.
- [10] R. B. Ljupkovi, R. D. Mi, M. D. Tomi, N. S. Radulovi, A. Lj, and A. R. Zarubica,

- “Significance of the structural properties of CaO catalyst in the production of biodiesel : An effect on the reduction of greenhouse gas emissions,” pp. 399–412.
- [11] N. Arun, R. V. Sharma, and A. K. Dalai, “Green diesel synthesis by hydrodeoxygenation of bio-based feedstocks: Strategies for catalyst design and development,” *Renew. Sustain. Energy Rev.*, vol. 48, pp. 240–255, 2015.
  - [12] Ž. Kesić, I. Lukić, M. Zdujić, L. Mojović, and D. Skala, “Calcium oxide based catalysts for biodiesel production: A review,” *Chem. Ind. Chem. Eng. Q.*, no. 0, pp. 10–10, 2016.
  - [13] H. Rutto and C. Enweremadu, “Optimization of production variables of biodiesel using calcium oxide as a heterogeneous catalyst : an optimized process,” no. Ccd, pp. 320–326, 2013.
  - [14] A. Islam, Y. H. Taufiq-Yap, E.-S. Chan, M. Moniruzzaman, S. Islam, and M. N. Nabi, “Advances in solid-catalytic and non-catalytic technologies for biodiesel production,” *Energy Convers. Manag.*, vol. 88, pp. 1200–1218, 2014.
  - [15] T. Maneerung, S. Kawi, Y. Dai, and C. Wang, “Sustainable biodiesel production via transesterification of waste cooking oil by using CaO catalysts prepared from chicken manure,” *Energy Convers. Manag.*, vol. 123, pp. 487–497, 2016.
  - [16] A. Buasri, N. Chaiyut, V. Loryuenyong, P. Worawanitchaphong, and S. Trongyong, “Calcium oxide derived from waste shells of mussel, cockle, and scallop as the heterogeneous catalyst for biodiesel production,” *Sci. World J.*, vol. 2013, 2013.
  - [17] M. Kouzu and J. S. Hidaka, “Transesterification of vegetable oil into biodiesel catalyzed by CaO: A review,” *Fuel*, vol. 93, pp. 1–12, 2012.
  - [18] A. Demirbas, “Biodiesel from sunflower oil in supercritical methanol with calcium oxide,” *Energy Convers. Manag.*, vol. 48, no. 3, pp. 937–941, 2007.
  - [19] D. M. Marinković *et al.*, “Calcium oxide as a promising heterogeneous catalyst for biodiesel production: Current state and perspectives,” *Renew. Sustain. Energy Rev.*, vol. 56, pp. 1387–1408, 2016.
  - [20] H. Li, S. Niu, C. Lu, and J. Li, “Calcium oxide functionalized with strontium as heterogeneous transesterification catalyst for biodiesel production,” *Fuel*, vol. 176, pp. 63–71, 2016.
  - [21] S. Yan, M. Kim, S. O. Salley, and K. Y. S. Ng, “Oil transesterification over calcium oxides modified with lanthanum,” *Appl. Catal. A Gen.*, vol. 360, no. 2, pp. 163–170, 2009.
  - [22] P. Mahanta and A. Shrivastava, “TECHNOLOGY DEVELOPMENT OF BIO-DIESEL AS AN ENERGY ALTERNATIVE,” pp. 1–19, 2004.
  - [23] A. R. Thakre, “KARANJ OIL - As a Substitute for Diesel,” vol. 4, no. 2, 2011.
  - [24] R. Anr, S. Aa, M. S. Islam, and S. Hamdan, “Active Heterogeneous CaO Catalyst Synthesis from Anadara granosa ( Kerang ) Seashells for Jatropha Biodiesel Production,” no. January, pp. 0–6, 2017.
  - [25] M. Naik, L. C. Meher, S. N. Naik, and L. M. Das, “Production of biodiesel from high free fatty acid Karanja ( Pongamia pinnata ) oil,” vol. 32, pp. 354–357, 2008.
  - [26] R. Anr, A. A. Saleh, M. S. Islam, S. Hamdan, and M. A. Maleque, “Biodiesel Production from Crude Jatropha Oil using a Highly Active Heterogeneous Nanocatalyst by Optimizing Transesterification Reaction Parameters,” *Energy and Fuels*, vol. 30, no. 1, pp. 334–343, 2016.
  - [27] S. N. Bobade and V. B. Khyade, “Preparation of Methyl Ester ( Biodiesel ) from Karanja ( Pongamia Pinnata ) Oil,” vol. 2, no. 8, pp. 43–50, 2012.
  - [28] M. A. Mane, “Karanja Oil as an Alternative Fuel for Direct Injection CI Engine- A

- Review,” vol. 2, no. 10, pp. 203–206, 2013.
- [29] S. Narayan, “Transesterification of karanja ( *Pongamia pinnata* ),” vol. 108, no. August, pp. 389–397, 2006.
- [30] H. M. Imran, A. H. Khan, M. S. Islam, R. S. Niher, A. Sujan, and A. M. S. Chowdhury, “Utilization of Karanja ( *Pongamia pinnata* ) as a Major Raw Material for the Production of Biodiesel,” vol. 60, no. 2, pp. 203–207, 2012.
- [31] P. Verma and M. P. Sharma, “Comparative analysis of effect of methanol and ethanol on Karanja biodiesel production and its optimisation,” *Fuel*, vol. 180, pp. 164–174, 2016.
- [32] S. Ismail, A. S. Ahmed, R. Anr, and S. Hamdan, “Biodiesel Production from Castor Oil by Using Calcium Oxide Derived from Mud Clam Shell,” vol. 2016, 2016.
- [33] A. N. R. Reddy, A. A. Saleh, M. S. Islam, and S. Hamdan, “Active Razor Shell CaO Catalyst Synthesis for *Jatropha* Methyl Ester Production via Optimized Two-Step Transesterification,” *J. Chem.*, vol. 2017, pp. 1–20, 2017.
- [34] Y. Ren *et al.*, “Ordered mesoporous metal oxides: synthesis and applications,” *Chem. Soc. Rev.*, vol. 41, no. 14, p. 4909, 2012.

## **AN AFFORDABLE CALIBRATED HOT BOX-HEAT FLOW METER SUITABLE FOR THERMAL PERFORMANCE MEASUREMENT OF AN INSULATION PANEL**

H.Jarimi<sup>1,2\*</sup> and Y.Wang<sup>1</sup>

<sup>1</sup>Department of Architecture and Built Environment, University of Nottingham,  
NG 2RD, United Kingdom

<sup>2</sup>Solar Energy Research Institute, Universiti Kebangsaan Malaysia  
43600 Bangi, Malaysia

\*Email: Hasila.jarimi@ukm.edu.my and celiax@126.com  
Phone: +603-8911 8572

### **ABSTRACT**

This paper presents a small affordable calibrated hot box built at the Department of Architecture and Built Environment, the University of Nottingham. Whilst no specific European Standards are available for the small calibrated hot box, at cost of approximately GBP 10,000 the design, development and utilisation of the hot box were performed by taking into account almost all the requirements outlined in the ISO 8990 standards. The hot box comprises of three components namely, the metering box, the specimen panel and the cold box. The box is designed by taking into account the minimum requirement for the metering area according ISO 8990 (1 m x 1 m). To ensure uniform air circulation at the specified air speed requirement, a baffle with a series of 12 Vdc fans was installed in each of the cold and hot area. Additionally, the minimum number of temperature sensors per unit area in measuring the thermal transmittance of the testing specimen have also been considered. The thermal transmittance value of the tested specimen was measured using a heat flux sensor. Innovative heating and cooling elements were introduced in the design of the hot box using two separate units of thermoelectric (TEC) air to air heat pump, capable to achieve 3° C to 45° C in the cold and hot enclosure respectively. The TEC heat pump is controlled by a proportional–integral–derivative controller (PID controller) connected to a PC with a user interface. Meanwhile the speed of the installed fans was controlled via Pulse Width Modulation (PWM) controller. To calibrate the hot box, the thermal conductivity of four different materials measured using the heat flux sensor in the hot box, were compared with the thermal conductivity measured using a calibrated guarded heat flow meter of Thermtest HFM-100. From the analysis, the values measured by the hot box and the guarded heat flow meter are found to be in good agreement with the average standard deviation of the measured *k*-value by the hot box from the guarded heat flow meter is below 10%. This paper serves as a guidance document that outline the methodology in the design, and development, in the specimen testing using heat flux sensor in a calibrated hot box.

**Keywords:** calibrated hot box, heat flow meter, *k*-value

## INTRODUCTION

Insulation material of a building are important indicators of the energy efficiency of the building. Therefore, it is very crucial to measure the thermal performance of the insulating material at high level of accuracy by taking into account suitable building standards. Reliable thermal transmittance data such as  $U$ -value and  $k$ -value are important since it allows us to; i) check the compatibility of the tested material in meeting regulations and specifications to acquire building certifications; ii) gain useful insights in evaluating the overall thermal performance of a designed building, iii) create a guidance to research the improvement of the performance of an insulation panel, and iv) compare the thermal performance of the researched panel with other types of high insulating material reported worldwide. Whilst no specific standards are available for the small calibrated hot box, the design, development and utilisation of the hot box were performed by taking into account closely the requirements outlined in the ISO 8990 [1] .

A similar design and construction have been discussed in [2] in which a small (0.9 m x 1.2 m [3' x 4'] opening) calibrated hotbox was used to study methods of improving window thermal performance; [3] on an affordable Hot Box Testing apparatus using ASTM C1363 standards for testing of straw bale and other non-conventional building panels; and [4] for the evaluation of the thermal properties of small specimens, in which EN ISO 8990 and EN ISO 12567 standards were being referred to in their study. In general, the standards can be categorised based on the methodologies which are available to determine the  $U$ -value which are the measurement method and calculation method. The former method will be the focus of this paper in which the thermal transmittance or  $k$ -value can be measured by means of a calibrated or guarded hot box method in accordance with EN ISO 8990.

## METHODS AND MATERIALS

### Materials

The testing samples were selected from the common insulation materials including wood panel (58.3 mm), polyurethane foam (23.4 mm), evacuated polyisocyanurate foam panel (61.2 mm) and the evacuated biomass aerogel panel (17.5 mm). All samples have the same length and width (30 mm x 30 mm). Sample was squeezed between two hollow square wood frames to have a consistent supporting function.

### Innovative low-cost hot box to measure thermal conductivity

We have designed an affordable small hot box as the facility to measure the thermal transmittance or  $U$ -value of glazing unit specimens and to produce thermal performance report for the tested specimens. As shown in figure 1 and figure 2, the box which provides warm air and represented indoors, is called metering box meanwhile the box which provides cool air and represented outdoors is call the cold box or the environmental chamber. The panel that hold the specimen is called the specimen panel. In the design of the hot box, the following important requirements of which some areas specified in ISO 8990 must be met:

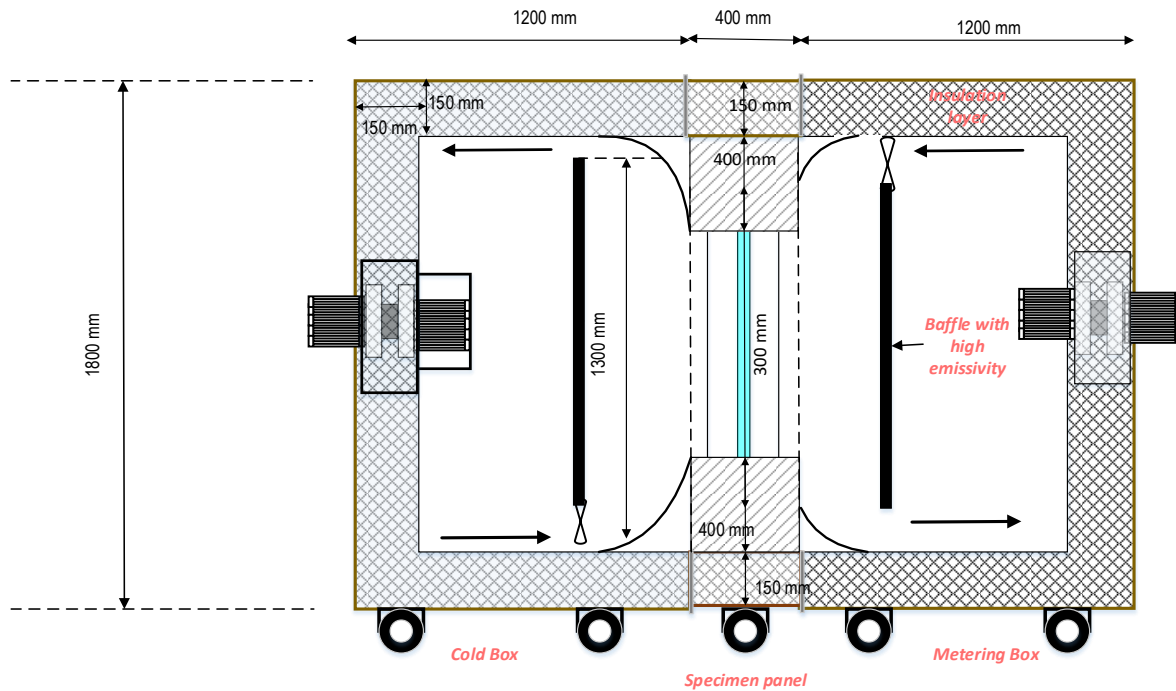
- Good wall insulation. The heat flow rate through the metering box wall must be small enough to be neglected.
- The box walls, perimeter seal and specimen shall form an air- and water-vapour-tight enclosure to avoid errors due to air and moisture transfer.

- Sealed plywood or plastic sheet on either side of the test specimen surround panel for rigidity and protection. The perimeter joints between the surround panel and the specimen should be sealed with tape, caulking or mastic material.
- The specimen must be placed centrally at least 200 mm from the inside surfaces of the cold and metering boxes.
- The minimum size of the metered area is 3 times specimen thickness or 1 m × 1 m, whichever is the greater.

The small hot box was constructed using Polyisocyanurate (PIR) insulation core from EcoTherm of 0.022 W/mK and at 150 mm thick. Profiles of MBS items were joint to house the Resin-bonded cellulose laminate sheets as the body of the metering box and also to protect the exterior of the insulation sheets. A care was taken while cutting the insulation cores in such a way that they were cut to fit exactly the body of the hot box and the inner joint of the insulation cores were sealed with tape to prevent air leakage. The overall internal volume of the hot box is designed at (1.105 m x 1.45 m x 1.45 m) in size, thus taking into account the minimum metering area as outlined in ISO 8990 (1 m x 1 m). An identical box which provide cooling for the calibrated hot box was designed and constructed.

In each box, a baffle which fits inside the metering box was placed at 150 mm distance from the surface of the specimen panel which is in accordance to the distance outlined in ISO 12567. A series of 12 Vdc fan was installed on the baffle to control air circulation thus the air speed of the metering and cold box respectively. While the focus of the affordable calibrated hot box is to measure the U-value of small size specimens, the specimen panel of the hot box was designed to be large enough to test a specimen at the maximum size of 1.45 m x 1.45 m. The metering box, specimen panel and the cold box are constructed to move on wheels and can be operated by only one person. In order to minimise the heat loss through the perimeter of the specimen, the edges of the metering and cold box that meet the specimen panel are fitted with a rubber gasket meanwhile the flat area of the insulation cores are fitted and protected with 1.5 mm thick black neoprene sheet. The assembly is closed tightly using a clamp mounted on the frame of the boxes. In order to supply heating and cooling to the system, an air to air thermoelectric heat pump (TEC-HP) AA PowerCool Series AA-100-24-22 of Laird at capacity of 102 W was used. The heat pump is environmentally friendly since no compressor or CFC refrigerants involved in the heating and cooling process. The principal of an air to air TEC-HP was based on the use of impingement flow to transfer heat. The heating and cooling of the environment is supplied by cooling the air flow via convection. For the metering box, heat carried by the air from the incoming air flow from outdoor environment will be absorbed and dissipated via high density heat exchangers with air ducted shrouds and fans. The heat will then be pumped and dissipated in the metering box by means of thermoelectric modules. A similar process applied for the cooling box, but with reversed polarity of electric current. In order to control the TEC heat pump to accommodate the metering and the hot box at specific temperature, the TEC heat pump is connected to PR-59 temperature controller which is designed to reversibly (cooling/heating) the thermoelectric assemblies. PR 59 comes with a precise temperature control accuracy which not only regulates the temperature, but also features two programmable fan outputs and an alarm output relay. The controller may be used as a stand-alone unit interface with RS-232 to read and control parameters and settings in real-time. An easy-to-use PC software is included for programming and visual review of output parameters. The temperature sensor which controls the output of the controller is NTC type thermistor which is located between the baffle and the specimen.

However, the reading of the temperature was first calibrated against the average measured value of air temperature from 17 thermocouple positions, placed near to the baffles.



**Figure 1.** The 2-D sketch of the calibrated hot box



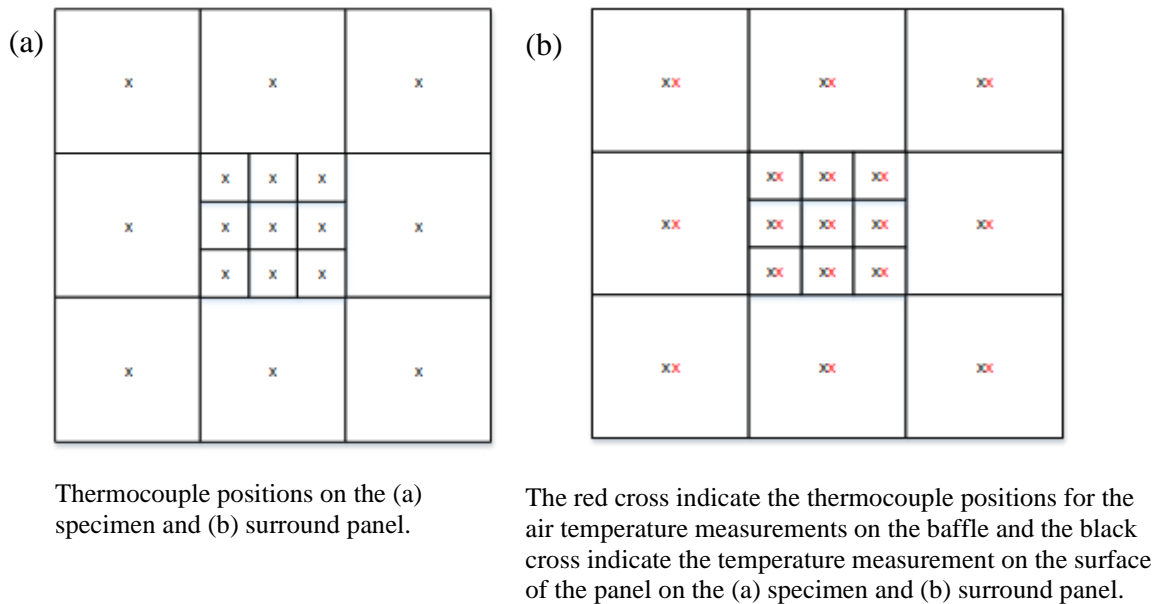
**Figure 2.** Clockwise: The constructed small calibrated hot box, the specimen area and the thermoelectric assembly unit for heating and cooling

Circulating fans will normally be needed to avoid stagnant air in the guard box. Thus, a series of 12 Vdc fans were arranged on the baffles along the vertical line parallel to the specimen and baffles surface for uniform heat supply and air circulation. The speed of the fans were controlled via a pulse-width modulation (PWM) controller. Temperature sensors of type T thermocouple (copper/constant) of 0.2 mm wire diameter were used to measure the specimen, baffles and air

temperature. A thermal adhesive tape is used to fix temperature sensors. The total number of sensors placed on the surface of specimen are nine. The same number of temperature sensors and the outlines were used for the air temperatures of which the reading shall be taken with a system having a suitable time constant and radiation shield. Thermocouples were installed at specific areas as illustrated in figure 3 and summarised in table 1. It is worth noted that, in order to monitor the heat flux rate from the metering area, in total of 16 thermocouples were placed on the inner surface of the metering wall. Meanwhile, the heat flux was measured using a heat flux sensor of hukesflux HP01.

**Table 2.** Thermocouple locations and the number of sensors

Area	Number of thermocouples
Specimen	9
Surround panel	8
Baffles-surface temperature (for each metering and cold box)	17
Baffles-air temperature (for each metering and cold box)	17
Walls of metering area	16



**Figure 3.** The thermocouple positions on the specimen and the surround panel (left) and on the baffle (right)

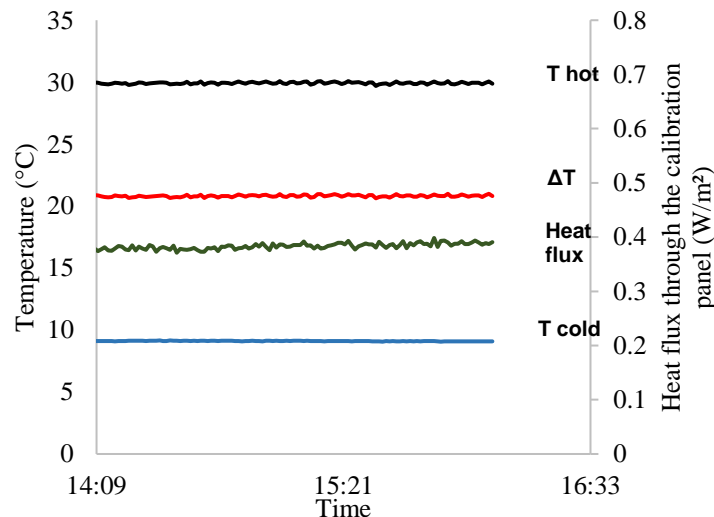
By referring to ISO 8990 standards, we have ensured that the following conditions are achieved by the calibrated hot box:

- The variation in air temperature across the air flow parallel to the specimen surface must not be more than 2% of the air to air temperature difference from the hot to the cold side. For example, if the temperature difference between the hot and cold side is 20 °C, the variations should not be larger than 0.4 °C (ISO 8990).

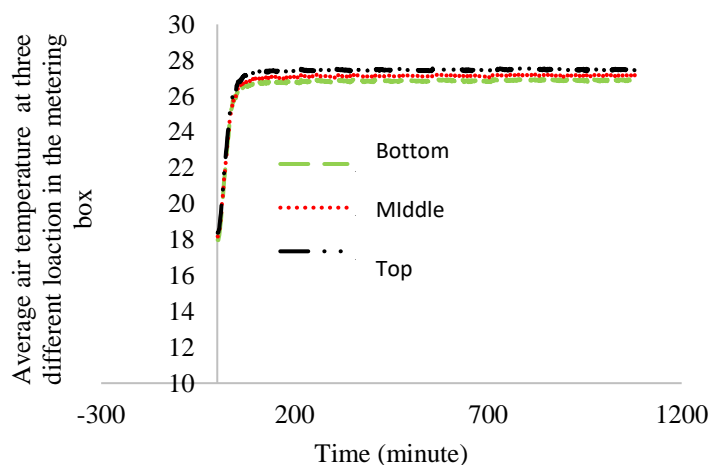


- Any air temperature gradients along long-direction of the air flow shall not exceed 2 K/m (ISO 8990)
- The air speed must be controlled in such a way that the heat loss through the metering box is as low as possible less than 30% of total heat input (ISO 8990)
- This initial check should cover the temperature uniformity and stability, air velocity and surface coefficients for both hot and cold side, the effect on accuracy of imbalance and, where appropriate, edge environment.

The time required for the steady state to be achieved varies, depending on the window specimen being tested. This is due to the fact that different materials have different thermal mass value. To check the temperature variation within the calibrated hot box, we have used an insulation layer at 150 mm thick. Figure 4 shows the measured temperatures and heat flux through the insulation layer at steady state condition. The recorded air temperature variation in front of the baffle per minute is  $2.5 \times 10^{-3} \text{ }^{\circ}\text{C}/\text{min}$  from figure 5 temperature uniformity parallel to the specimen is clearly not an issue with the temperature variation across the air channel in front of the specimen is less than  $0.4 \text{ }^{\circ}\text{C}$ .



**Figure 4.** The measured temperatures and heat flux through the insulation layer



**Figure 5.** Average air temperature at three different locations in the metering box in front of the specimen

In order to validate the reading measured by the low-cost calibrated hot box, the measurements were compared with the reading obtained using a calibrated guarded heat flow meter of Thermtest HFM-100 Device which will be discussed in the next section.

### THERMTEST HFM-100 Device

All samples were measured by a guarded heat flow meter (Thermtest HFM-100) belongs to the heat flow method. Sample was positioned between two different temperature plates, which produce a fixed temperature difference ( $\Delta T$ ). The heat flux generated by the stable temperature difference which is monitored by heat flux sensor integrated into each plate. The thermal conductivity ( $\lambda$ ) and thermal resistance are calculated by using this stable heat flux according to Fourier's law. In this experiment, the equipment was put on a stable desk as shown in figure 6. The upper plate as the heating source set at 35 °C and bottom plate as the cooling source set as 15 °C. The exact thickness of samples could be measured during the test.



**Figure 6.** The Thermtest HFM-100 device.

## RESULTS AND DISCUSSION

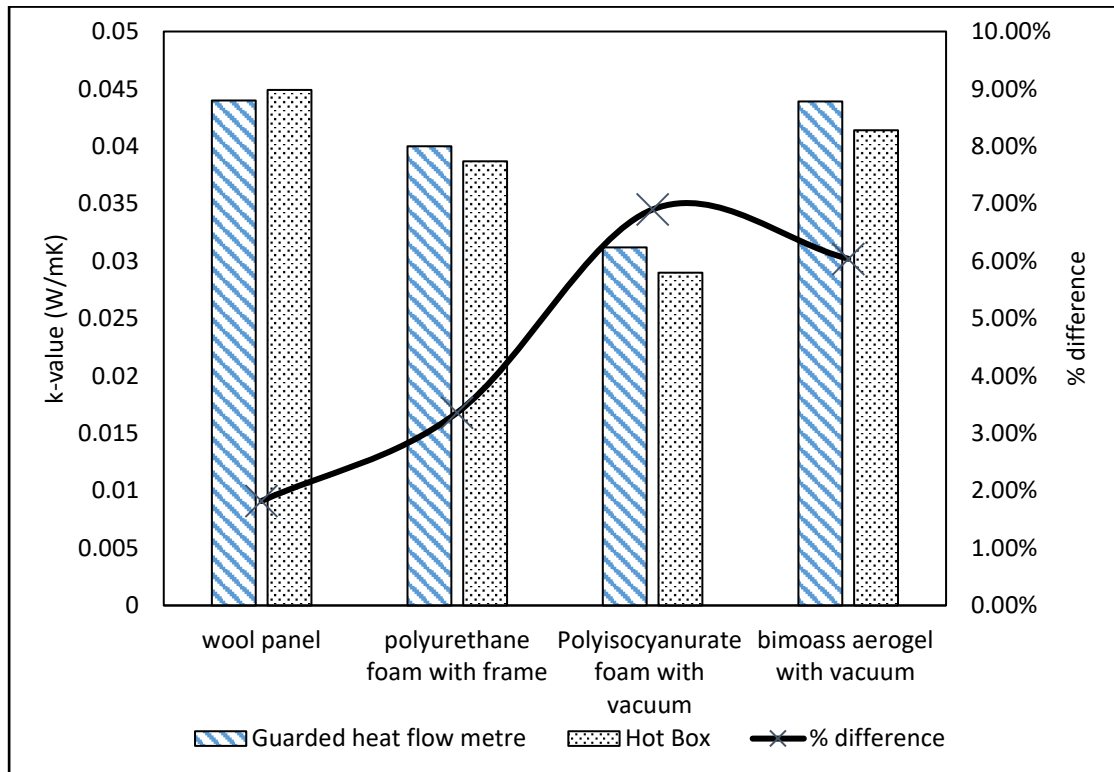
Table 2 and figure 7 show the average hot  $T_{hot}$  and cold surface temperature  $T_{cold}$  (measured at different 9 locations), and the heat flux of the measured sample. Using the calibrated hot box, the readings were taken for 120 minutes at a stable condition. The average value of the parameters was measured by averaging the recorded data over the measurement period. Meanwhile the  $k$ -value or the thermal conductivity of the samples were computed using the following equation:

$$k = \frac{\phi_{sample}}{\bar{T}_{hot} - \bar{T}_{cold}} \times \delta \quad (1)$$

where,  $k$  is the  $k$ -value or the thermal conductivity,  $\bar{T}_{hot}$  and  $\bar{T}_{cold}$  are the average measured temperature for the hot and cold surface in Kelvin (K) respectively,  $\phi_{sample}$  is the measured heat flux using the heat flux sensor in W/m<sup>2</sup> and  $\delta$  is thickness of the sample.

**Table 3:** The summary of the k-value measured using the calibrated hot box and the guarded heat flow meter.

Sample	Thickness (mm)	Thermal conductivity (W/mK) using low- cost calibrated hot box	Thermal conductivity (W/mK) using Guarded heat flow meter		The percentage difference (%)
Wool panel	10.8	0.0440	0.0449	0.000817	1.82%
Polyurethane foam with frame	23.4	0.0400	0.0387	0.0013	3.36%
Polyisocyanurate foam with vacuum	61.2	0.0312	0.0290	0.002	6.90%
biomass aerogel with vacuum	17.5	0.0439	0.0414	0.0025	6.04%



**Figure 7.** The comparison between the k-value measured using the calibrated hot box and the guarded heat flow meter

Table 2 summarises the analysis from the analysis, the values measured by the hot box and the guarded heat flow meter are found to be in good agreement. We found that, the average standard deviation of the measured k-value by the hot box from the guarded heat flow meter is below 10% and hence the reliability of the calibrated hot box in measuring the thermal performance of the insulation panels is confirmed.

## CONCLUSIONS

While the design and performance of the hot box apparatus does not exactly meet the requirements of ISO standards, it follows closely the requirements outlined in the standards and its affordable design enables reliable testing of various glazing samples. With cost of approximately GBP 10,000 makes the calibrated hot box accessible to academic institution that have limited funding. Although the size of the calibrated hot box smaller in comparison to a typical guarded hot box, the temperature fluctuation is not an issue. The use of baffles and thermoelectric air to air heat pump as a heater and cooler for the calibrated hot box, controlled by the PID controller definitely help to achieve uniform temperature profiles in both the metering and cold boxes. Nevertheless, for the current hotbox design, the minimum temperature achievable by the cold box is limited to 3 °C. It is expected that by replacing the thermoelectric air to air heat pump with higher in capacity could provide additional gains in minimal temperature level achievable by the cold box.

## ACKNOWLEDGEMENTS

The authors gratefully acknowledge Innovate UK's financial support through Newton Fund with China (project reference no: 102882).

## REFERENCES

- [1] B. S. I. (BSI), "BS EN ISO 8990:1996. Thermal insulation. Determination of steady-state thermal transmission properties. Calibrated and guarded hot box," ed: BSI, 1996.
- [2] H. K. Joseph, "A Calibrated Hotbox for Testing Window Systems - Construction, Calibration, and Measurements on Prototype High-Performance Windows," *ASHRAE Transactions*, vol. 85, 1981.
- [3] S. Seitz and C. MacDougall, "Design of an Affordable Hot Box Testing Apparatus," presented at the 16th NOCMAT, Winnipeg, Canada, 2015.
- [4] C. Buratti, E. Belloni, L. Lunghi, and M. Barbanera, "Thermal Conductivity Measurements By Means of a New 'Small Hot-Box' Apparatus: Manufacturing, Calibration and Preliminary Experimental Tests on Different Materials," *International Journal of Thermophysics*, vol. 37, p. 47, March 11 2016.

## **PRELIMINARY EXPERIMENTAL STUDY OF PASSIVE SOLAR AIR HEATING SYSTEM IN DRYING CHILLI UNDER MALAYSIAN CLIMATES**

Abdalla Abdur Rahman Shahbal<sup>1</sup> and Khai Mun Ng<sup>2,\*</sup>

<sup>1,2</sup> Mechanical & Automotive Engineering, Faculty of Engineering, Science & Technology, Infrastructure University Kuala Lumpur, 43000 Kajang, Selangor, Malaysia.

\*Corresponding author email: ngkmun@iukl.edu.my

### **ABSTRACT**

In this paper, a preliminary experimental investigation of a passive solar air heating system in drying an agricultural product, chilli, under the Malaysian climates was presented. 10 days outdoor experimental works were conducted, in which the recorded parameters were solar irradiance, mass of chilli, temperature around the system and thermal mapping of the system. Results showed that the maximum average temperature attained by the solar absorber was recorded at about 80°C. The temperature on the bottom tray of the system was found to be higher than the temperature on its upper tray. Outcome indicated that the developed passive solar air heating system could enhance the drying rate as compared to the conventional direct sun drying method. It showed that the percentage of moisture removal was about 74% when using the passive solar air heating unit, meanwhile it was recorded at about 54% when applying the direct sun drying method, indicating that the passive solar air heater has outperformed the direct sun drying method, with approximately 20% better drying rate. A linear correlation has been developed that the absorber temperature could be predicted at a moderate accuracy by knowing the solar radiation data with  $R^2 = 0.6881$ .

Keywords: Passive solar air heating system, Malaysian climate, chilli

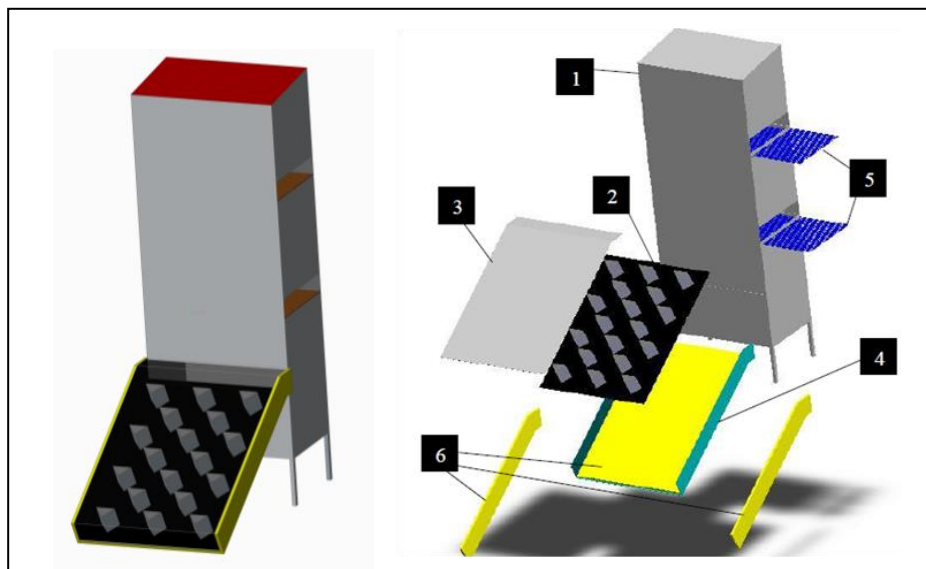
### **INTRODUCTION**

Drying is a traditional method applied to preserve food products for a long period of time. Since centuries ago, people remove the moisture content of a food product by exposing it directly under the sun. However, this method has many disadvantages such as it is time consuming, labour intensive, hygienically questionable as well as easily affected by the weather like strong wind, raining and dusty sky. One of the common solutions in this drying application is to use a solar air heating system. Recently, the solar air heating system technology has been a substitute method for drying food products as it can treat the products in a safe, clean and hygienic as well as preserving their quality and nutrient. Many commodities, particularly agricultural products, are dried to extend their storage period on a commercial scale such as banana, guava, grapes, wheat, corn, rice, chilli and etc. The use of solar air heating system could be more economical and efficient for a large scale of drying application, which could potentially promote the agriculture-based economy in urban areas. Besides, the solar air heating system could save electricity, time and labour [1]. In general, there are two types of solar air heating systems, known as active and

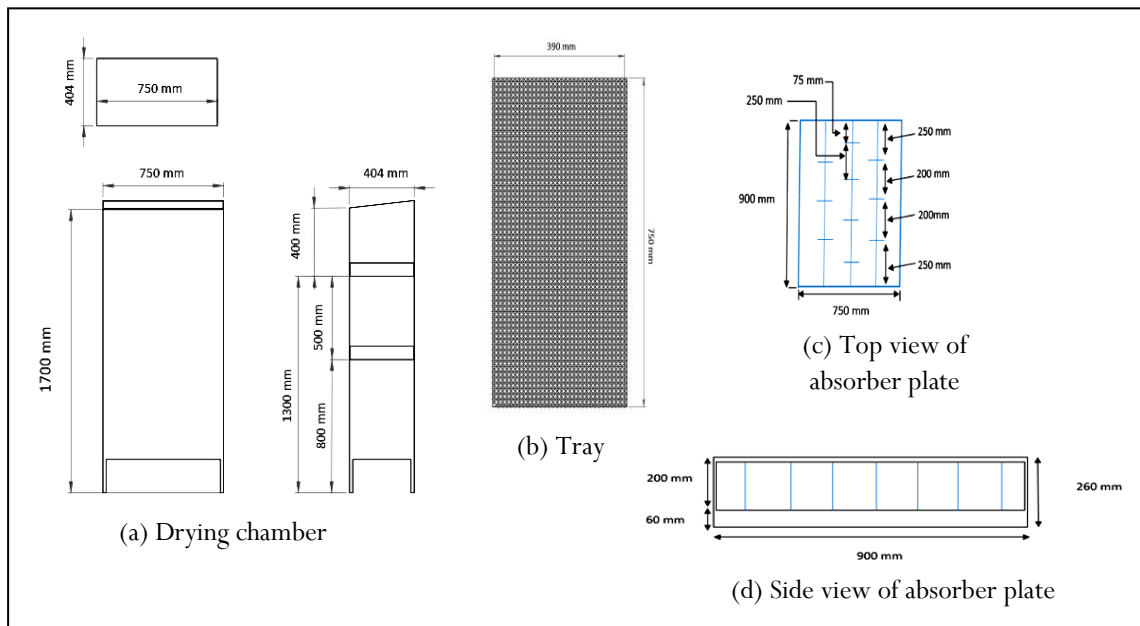
passive systems. The active solar air heating system requires external force to operate the system, such as fans or blowers; while the passive solar air heating system relies on a natural air circulation. Malaysia, located near to the equator, is always perceived to have a great potential in harvesting solar energy for various solar applications. Its monthly average daily solar radiation intensity is prominent which is possibly over  $17\text{MJ}/\text{m}^2$  [2, 3]. Thus, the use of solar air heating system in drying the agricultural products under the Malaysian climates should be promising. The objective of this study is to carry out a preliminary field test to investigate the performance of a passive solar air heating system in drying an agricultural product under the Malaysian climates, and compare its performance with the conventional sun drying method. In the present work, the passive solar air heating system was developed which was tested outdoors for 10 days. This is to note that only one agricultural product was selected in the experimental work, which is red chilli (*Capsicum annum*). The detailed experimental approach is presented in the following section.

### EXPERIMENTAL SETUP AND MEASURING

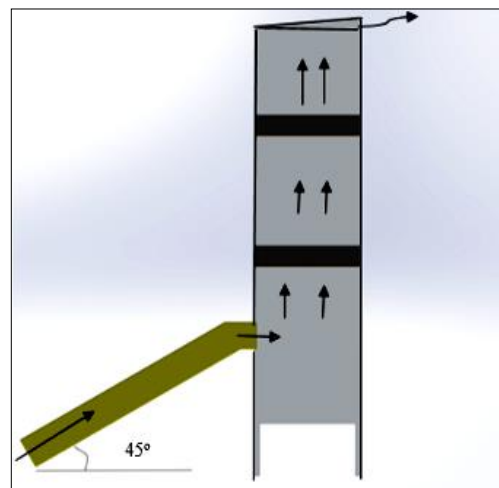
In this work, the passive solar air heating unit was modelled in a 3D drawing using SolidWorks software as shown in figure 1. The components are illustrated in the exploded view, which are: (1) drying chamber, (2) absorber plate, (3) transparent cover, (4) absorber base, (5) 2 layers of trays and (6) insulation material. Figure 2 shows the dimension of several main components. Figure 3 indicates the direction of air flow in the unit. Note that the temperature inside the chamber should be less than the temperature of the absorber plate to create a temperature gradient which eventually causing the passive air flow from the absorber plate to the drying chamber in the upward direction. The actual fabricated unit is illustrated in figure 4.



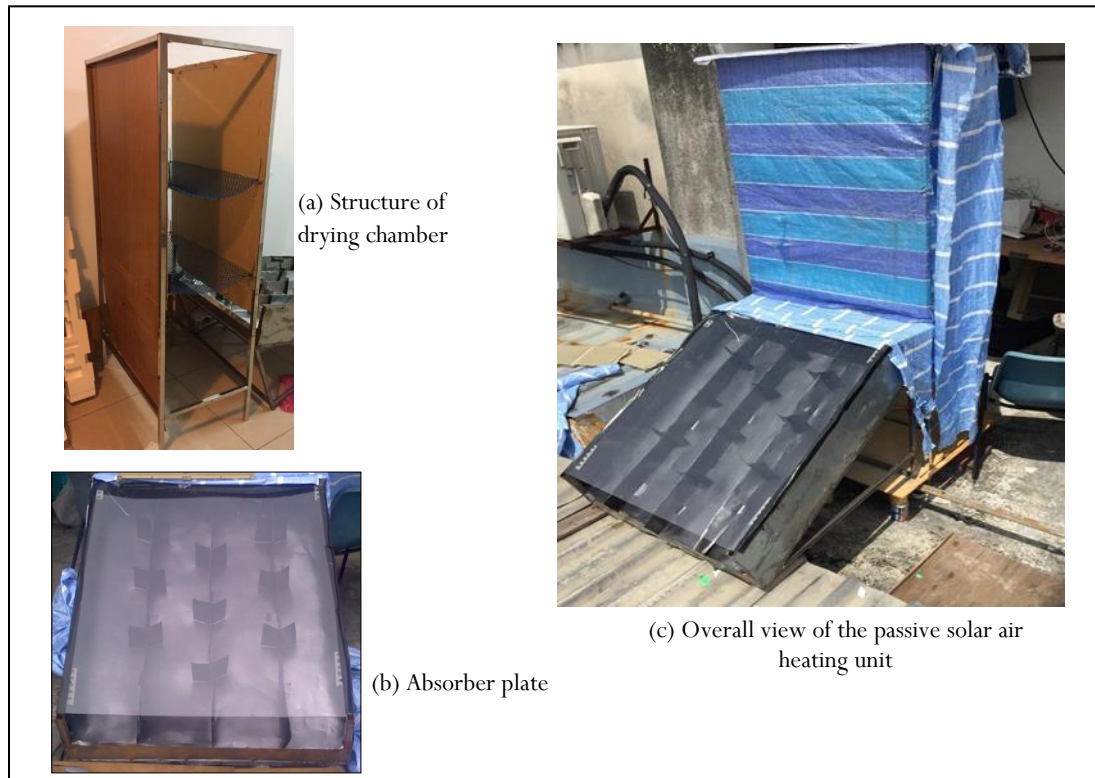
**Figure 1.** 3D model of passive solar air heating unit



**Figure 2.** Dimensions of main components of passive solar air heating unit



**Figure 3.** Air Flow Direction



**Figure 4.** Actual unit

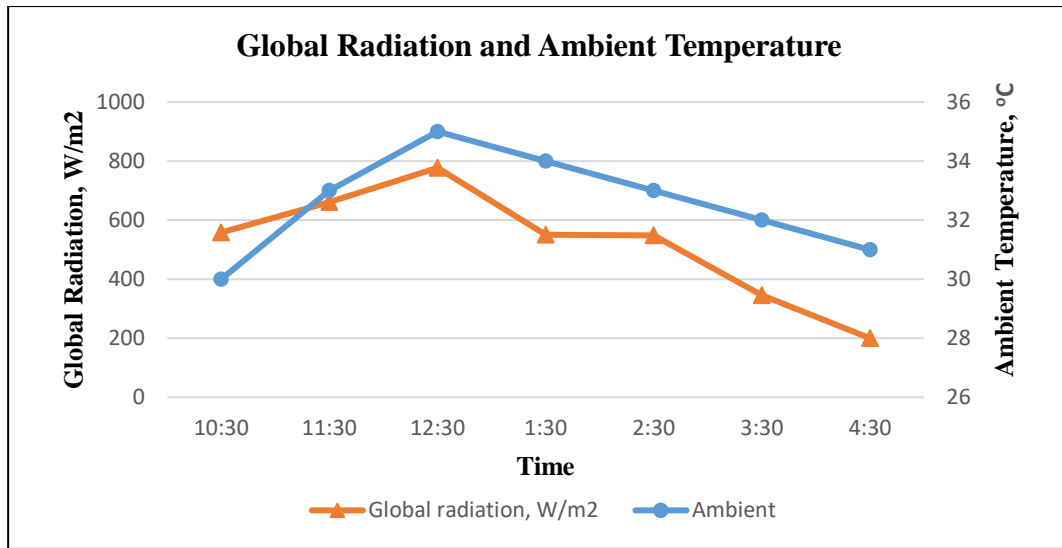
The measuring devices used in the present work were data logger model DT80G, pyranometer, electronic scale, Flir thermal infrared camera and type-K thermocouple. Pyranometer, electronic scale and thermocouple were used to measure the solar irradiance, mass of chilli and temperature around the system, respectively. The thermal infrared camera was employed to visualise the thermal mapping of the system.

The outdoor experiment was conducted at the roof of the Block 3 of IUKL located at latitude of  $2^{\circ}58'N$  and longitude of  $101^{\circ}44'E$ . The experiment was carried out from 10:30am to 4:30pm for 10 days. The data collection using the data logging system to measure the temperature and global irradiance, were recorded in 2 minutes interval; meanwhile the data collection for the chilli mass was recorded after 1 day of drying process. In this work, the experiment was carried out for 2 scenarios: (1) chilli drying by using the passive solar air heating unit and (2) chilli drying under the sun directly in open area. The initial mass of the chilli before commencing the drying process for both scenarios was set at 500g. The measured temperature points were ambient, solar absorber and inner compartment of the drying chamber at tray 1 and tray 2.

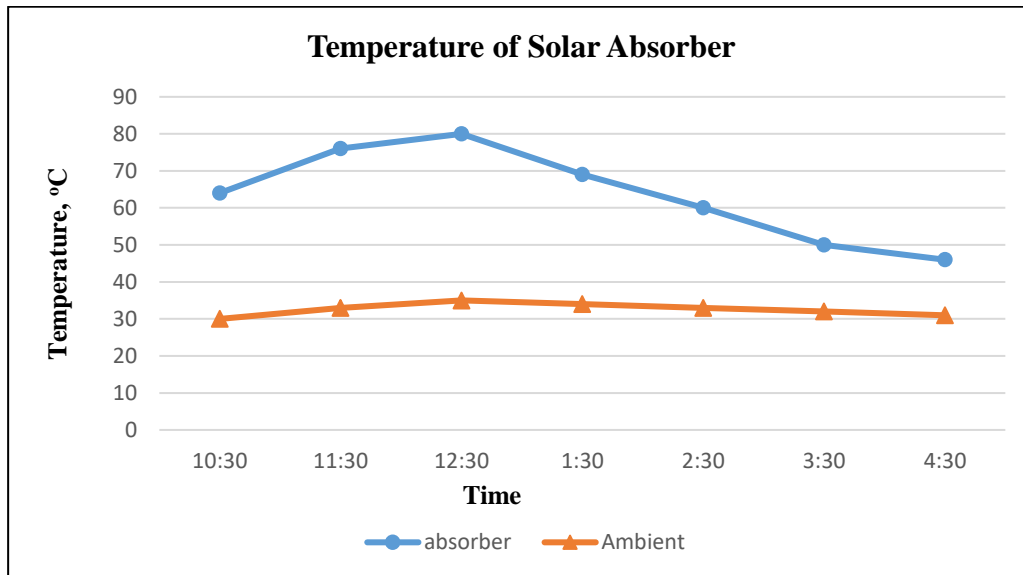
## RESULTS AND DISCUSSION

Figure 5 shows the relation between the global radiation and ambient temperature. One can see that the temperature is strongly dependent on the solar radiation intensity. It reached its peak during the noontime as expected. Figure 6 indicates the variation of solar absorber temperature during a daytime. The temperature was recorded at peak during 12:30pm at about  $80^{\circ}C$  in average, in which the respective average ambient temperature was about  $34^{\circ}C$ . The high temperature gradient has shown that the system was performing as expected to be the passive solar air heating which was capable to induce the heated air flowing upward.





**Figure 5.** Global radiation and ambient temperature



**Figure 6.** Temperature of solar absorber

Figure 7 shows the chamber temperatures at 2 trays. The average temperature on the lower tray (tray 1) reached a maximum value of 44°C and the average temperature on the upper tray (tray 2) reached a maximum value of 43°C. The temperature on the bottom tray (tray 1) was found out to be higher than the temperature on upper tray (tray 2). This phenomenon was reasonable as the solar thermal heat would be first reaching this section. The result showed that the temperature inside the drying chamber was about 9°C higher than the ambient temperature. The field studies of other researchers working on the solar drying system for chilli had reported the similar temperature trend profile in a daytime drying process [4, 5]. Figure 6 and 7 indicate the same trend pattern as the global radiation intensity. The overall trends of the graphs showed that solar air heater was capable to operate well for the drying process.

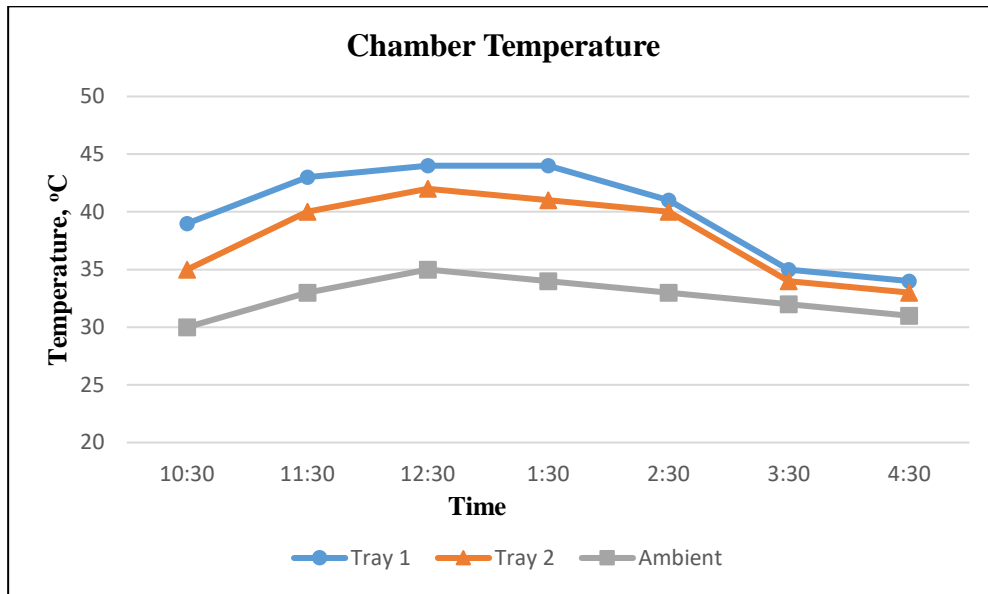


Figure 7. Chamber temperature

Figure 8 presents the clear heat movement and temperature gradient on the surface of the solar absorber during the drying process. Figure 9 shows the chilli inside the drying chamber and its thermal mapping. It showed that the chilli was heated up by the hot air induced into the chamber from the solar absorber passively. Result showed that the chilli could be heated up to 46°C.

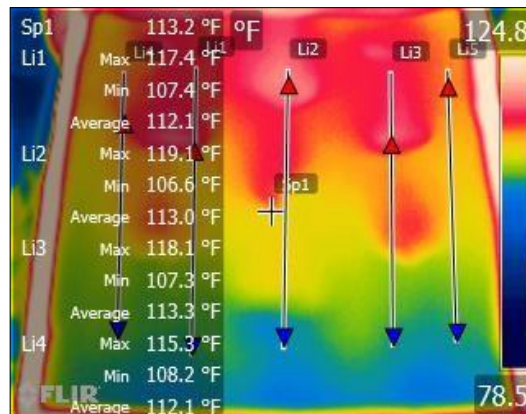


Figure 8. Thermal mapping of the solar absorber

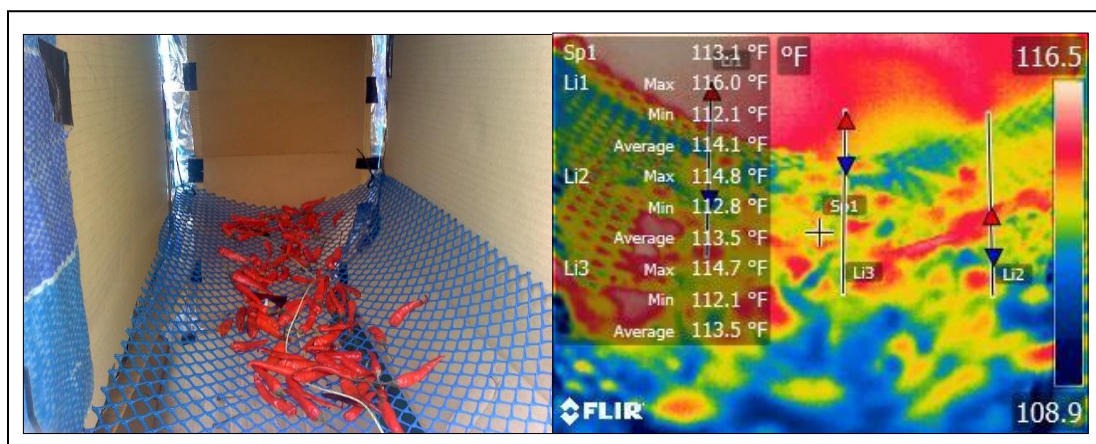
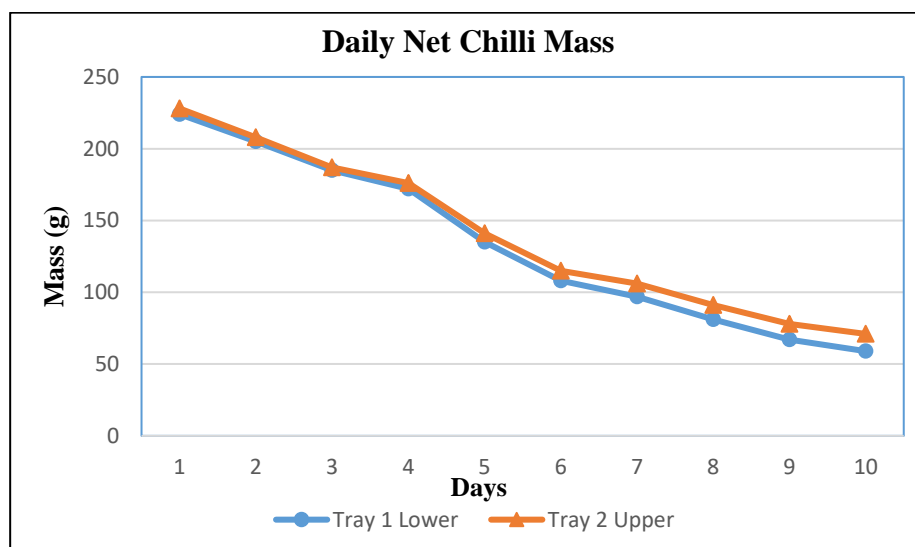


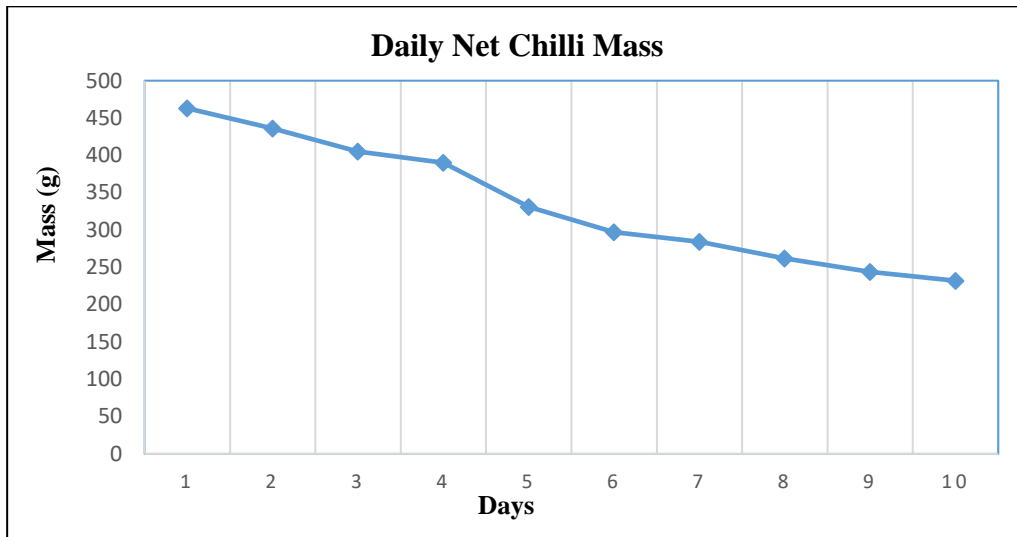
Figure 9. Chilli inside drying chamber and its thermal mapping

Figure 10 depicts the daily net chilli mass in tray 1 and tray 2. When the hot air rises up through the drying chamber, it accelerates the vaporisation process of the moisture content inside the chilli and therefore removing the moisture content from the chilli on the trays. This causes reduction in the mass due to the moisture loss in the chilli. The chilli was initially having a mass of 250g for each tray. The mass was reduced to about 187g after 3 days, which was about 25% mass reduction. The drying process continued to the fourth day with a relatively mild reduction in mass due to the raining and cloudy weather on that day. On the fifth day, the mass of chilli in the tray 1 was reduced to 135g; meanwhile the mass of chilli in tray 2 was reduced to 141g. The drying process continued until the day 10, in which the total amount of moisture content removal was about 370g, equivalent to 74% of mass reduction. One could observe that the mass reduction in tray 1 was higher which was consistent with the result in figure 7 indicating that the higher temperature would induce higher rate of vaporisation, and therefore higher mass reduction due to greater moisture content removal.

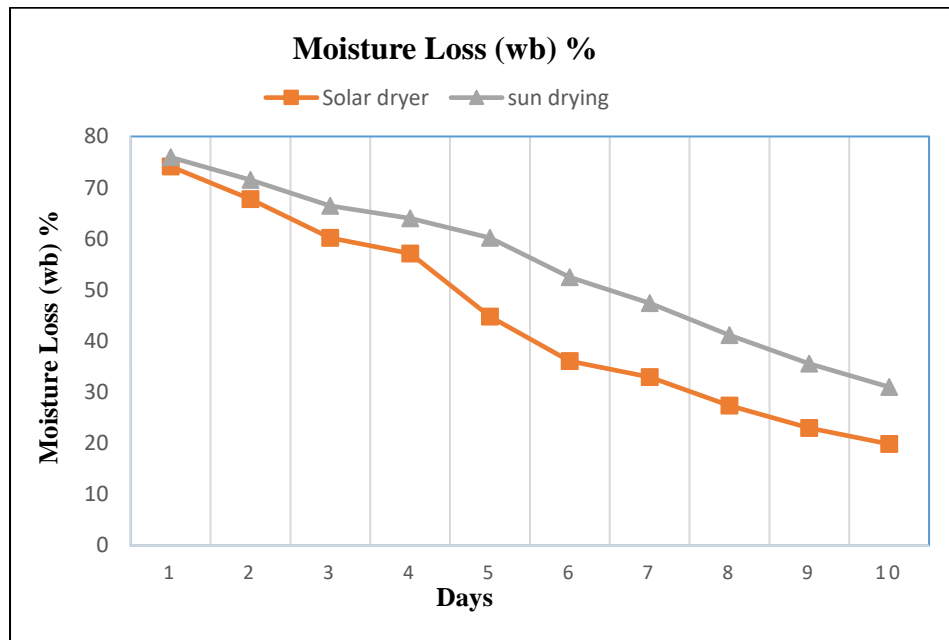


**Figure 10.** Daily net chilli mass in tray 1 and tray 2

Figure 11 shows the result of the daily net chilli mass dried under the direct sun in the open area. It presented the similar trend profile as in the figure 10. After the 10 days drying process, its mass was reduced by 272g, equivalent to 54.4% of mass reduction. Figure 12 indicates the comparison for both drying scenarios in term of moisture loss. The result is consistent with the outcomes presented by [5, 6], which had demonstrated a fairly similar trend pattern. It was noticed that the difference of drying rates between the passive solar air drying and the direct sun drying was relatively small during the initial stage. However, as drying progressed, the rate of moisture loss in the passive solar air heater has become higher. From the result, the passive solar air heater has outperformed the direct sun drying, with about 20% better drying rate.

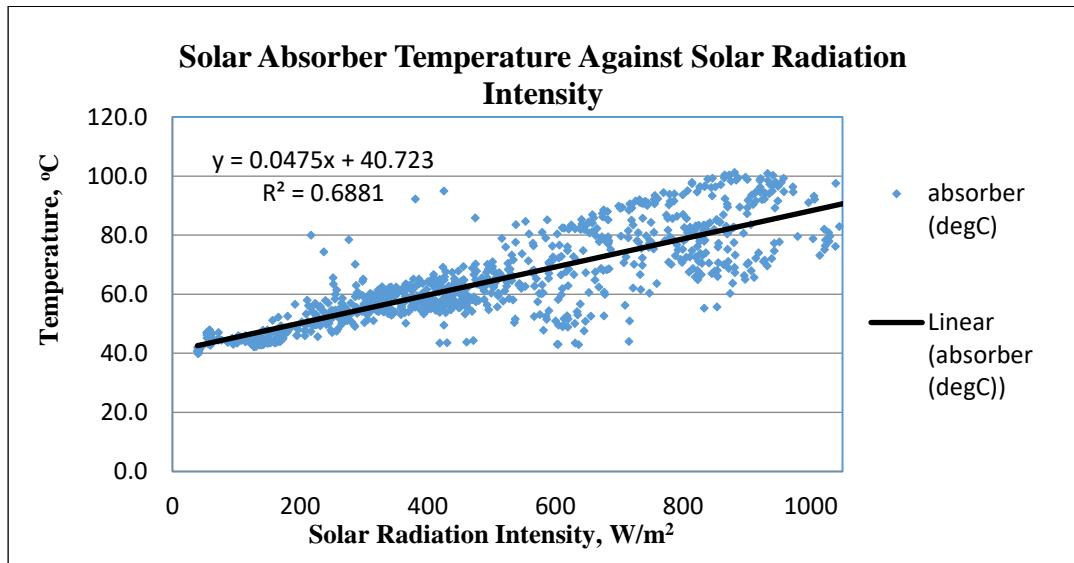


**Figure 11.** Daily net chilli mass for open area drying under the direct sun



**Figure 12.** Comparison of daily moisture loss of chilli for the drying process using the passive solar air heating unit and the direct sun drying in open area

According to the observation at the experimental site, the passive solar heating unit could protect the chilli from heavy rain and strong wind. In contrary, for the direct sun drying method, it required much care and labour to save the chilli from being spoiled by the rain and wind. It could be more noticeable if the scale of drying process is big. Figure 13 shows the linear correlation between the solar absorber temperature and solar radiation intensity. It showed that when the solar radiation increased, the absorber temperature increased too. The linear correlation indicated that the absorber temperature could be predicted at a moderate accuracy by knowing the solar radiation data with  $R^2 = 0.6881$ .



**Figure 13.** Relation between solar radiation intensity and solar absorber temperature

## CONCLUSION

In this work, the outdoor performance of a passive solar air heating system in drying an agricultural product, chilli, under the Malaysian climates was presented. The maximum average temperature achieved by the solar absorber was recorded at about 80°C. The temperature on the bottom tray was found out to be higher than the temperature on the upper tray. The developed system could enhance the drying rate as compared to the conventional direct sun drying. Results showed that the mass of moisture removal for 500g of chilli was 370g when using the passive solar air heating unit, meanwhile the mass of moisture removal was merely about 272g when applying the direct sun drying method. The drying rate of the passive solar air heater was 20% better than the direct sun drying. The present work has demonstrated the positive prospect of using the simple passive solar air heating system for drying the agricultural product under the Malaysian sky, thus more research work should be encouraged in this aspect to attain the value of commercialisation.

## REFERENCES

- [1] Tarigan, E., *Mathematical modeling and simulation of a solar agricultural dryer with back-up biomass burner and thermal storage*. Case Studies in Thermal Engineering, 2018. **12**: p. 149-165.
- [2] Ng, K.M., N.M. Adam, O. Inayatullah, and M.Z.A.A. Kadir, *Assessment of solar radiation on diversely oriented surfaces and optimum tilts for solar absorbers in Malaysian tropical latitude*. International Journal of Energy and Environmental Engineering, 2014. **5**(1): p. 5.
- [3] Ng, K.M., N.M. Adam, and M.Z.A. Ab Kadir, *Experimental investigation of shading facade-integrated solar absorber system under hot tropical climate*. Journal of Building Engineering, 2019. **23**: p. 136-143.

- [4] Chatchawal, N., Roongrojana, S., Sirichai, T., and Veerapol, M., *Experimental research of drying red chili by two methods: solar drying and low-temperature system drying*. Energy Procedia, 2017. **138**: p. 512-517.
- [5] Kamble, A., I.L.Pardeshi, Singh, P., and Ade, G., *Drying of chilli using solar cabinet dryer coupled with gravel bed heat storage*. Journal of Food Research and Technology, 2013. **1**(2): p. 87-94.
- [6] Muhammad Zakaria, H., M. A., H., Md. Abdul, A., Md. Masud, A., and A.H.M., M. R, *Design and development of solar dryer for chilli drying*. International Journal of Research (IJR), 2015. **2**(1), 63 - 78.

## PROSPECT EVALUATION OF A WIND FARM PROJECT FOR A SMART CAMPUS IN THE FEDERAL UNIVERSITY OF KASHERE, GOMBE STATE

Michael C. Ohakwere-Eze<sup>1,\*</sup>, Righteous Ombu<sup>2</sup>, Udo A. A<sup>1</sup> and Mela S. Shimo<sup>1</sup>.

<sup>1,\*</sup>Department of Physics, Federal University of Kashere, Gombe State, Nigeria

<sup>2</sup>Department of Physics, Federal Polytechnic Ekowe, Bayelsa State, Nigeria

\*Corresponding author email; michael.ohakwereze@gmail.com

Phone number; +234 7035746293

### ABSTRACT

The sources of energy we use in our day-day activities contributes significantly to the alarming global warming which the world is currently experiencing. A technical solution to the menace of an environmental friendly, sustainable and reliable energy is the peak of this research. 2014-2017 years' wind speed data measured at a height of 2m were analyzed using the Weibull's distribution method. The results show that all through the studied years and seasons, the mean wind speed distribution for the rainy season showed significant stability as seen from K-values. However, the dry season has the highest K-value of 2.08 signifying more stable winds during the season. The monthly averages, computed for height of 60m above ground level ranges between 2.15m/s and 6.42m/s with the maximum wind speed in June while the minimum wind speed occurred in September. This implies that the wind velocity of the study area tends to be lower during the end of the rainy season. Nevertheless, the deviation in the mean wind speed was not significant, as such wind energy can serve as a reliable energy source for the campus hence could be harvested.

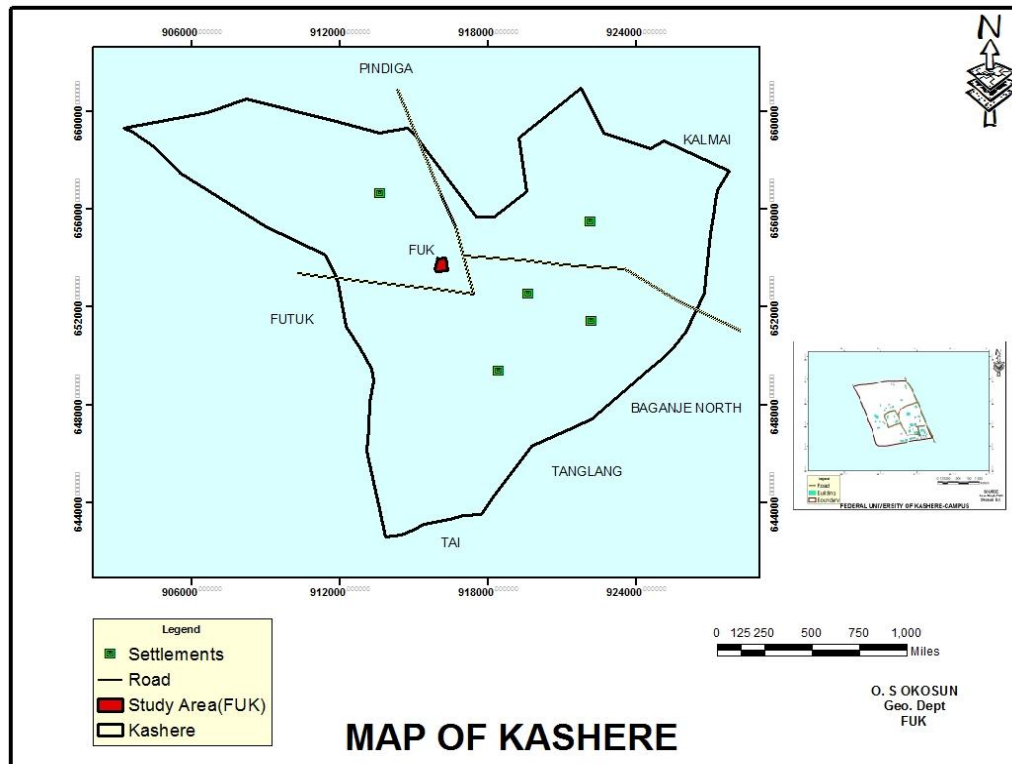
**Keywords:** renewable energy, wind energy, weibull distribution, wind speed.

### INTRODUCTION

Since its commercial advent in the 1970s, renewable energy has become increasingly popular to investors, government officials and the general public. The awakening of significant investments in renewable energy was motivated by a growing realization of the need for energy security. This need for energy security was visualized in the 1970s when there were oil shortages in the United State (Mark *et al.*, 2018). The oil shortages created an interest in developing ways to use alternative energy sources, such as wind energy, hydropower, geothermal power and so forth. Fortunately, the alternative means of tackling the menace of energy security was to harness renewable energy, for short wind energy. Since then, scholars, scientist and engineers developed kin interest in renewable energy.

The ever-growing need of energy has boost the usage and search for whatever form of energy. Unfortunately, some forms of energy have a lot of negative impacts on both the social, economic and physical environment. As suggested by many scholars, the way forward is to seek an energy source which will be; environmental friendly, a release from economic burden and socially acceptable. These make the problem which this research seek to provide a technical solution.

Hence the aim of this research is to evaluate the possibility of a wind farm that will meet the energy requirement of Federal University of Kashere, Gombe State. To achieve this, two objectives are set which are to determine the average wind speed of the geographical ranges of Federal University of Kashere and to obtain the wind distribution all through the year and the seasons. The study area which is the Federal University of Kashere (FUK), is located in Akko Local Government Area of Gombe state, North East Nigeria and has a geographical coordinate; latitude: 9.9128°N, longitude: 11.0065°E. It is located on an elevation 431 meters above sea level (Figure 1).



**Figure 1.** Location map of the study area.

Wind energy is the fastest growing source of energy and is getting worldwide attention due to technological advances for harnessing the wind power and its competitive cost of production as compared to other traditional means. Of these clean sources, the rapid development in wind energy conversion technology has made it an alternative to conventional energy system in recent years (Alam et al., 2011). In order to conserve the conventional energy resources, and to address the environmental problems, the wind power utilization is the answer to these problems. Wind power has progressed from been a minor source of electricity to a technology that attracted many countries to it. In Nigeria, Oluseyi et al., (2014) investigated the average wind speed in south western part of the country and the corresponding cost analysis showed that generation cost can be as low as 0.02KW/h and as high as 5.03KW/h. Ulan, (2013) analyzed wind power generation with a null hypothesis that “there is no significant difference in the wind velocity means” with the use of custom-constructed wind guide attachment. Unfortunately, the statistical analysis (ANOVA) rejected the null hypothesis which means the reverse might be the case. Oyedepo et al., (2012) examined the wind speed in three south-eastern states, Nigeria. He reported the annual wind speed at height of 10m for Enugu, Owerri and Onitsha to be 5.42, 3.36 and 3.59m/s



respectively. The minimum wind speed recommended to turn a wind turbine for power generation is 12.6km/h (3.5m/s). Ohunakin (2011) assessed the annual mean wind speeds of five states in the north-central region and obtained 2.75, 4.29, 4.57, 4.39 and 3.16m/s for Bida, Minna, Makurdi, Ilorin and Lokoja in that order.

Wind power apart from its reliability has several benefits such as industrial growth, clean fuel source, sustainability and many others. Wind power is recognized as an important contributor to renewable energy, climate, and energy security targets set by many countries across the globe. For this and many other related reasons, the use of wind energy has continued to expand, and will play an important role in the production of electricity in the future. Moreover, wind is a natural occurrence and harvesting its kinetic energy doesn't affect current and wind cycles in any way and the kinetic energy in the wind is a promising source of renewable energy with significant potentials in many parts of the world (Abdeen, 2011). Obviously, this form of energy seems to be the way forward and therefore serves as a technical solution of an effective remedy to fossil – fuel depletion, which satisfy the millennium Development Goals (MDGs).

### 1.1 Wind Velocity (Speed)

Wind speeds are crucial in the development of wind energy conversion system. (Abdulkarim et al., 2017).

Let the mean wind speed of the site be  $V_m$ , then it can be obtained from the equation;

$$V_m = \frac{1}{N} \sum_{i=1}^N v_i \quad (1)$$

Where  $v_i$  is the observed (recorded) wind speed and N is the data point. However, the root mean cube (RMC) speed  $V_{rmc}$  given by;

$$V_{rmc} = \sqrt[3]{\frac{1}{N} \sum_{i=1}^N V_i^3} \quad (2)$$

Fortunately, the wind power ( $P_w$ ) can be expressed in terms of wind speed

$$P_w = \frac{1}{2} \rho V_{rmc}^3 \quad (3)$$

Where  $\rho$  = observed air density.

### 1.2 The Weibull Probability Distribution Function (PDF)

Knowledge of the wind speed frequency distribution plays an important role for the estimation of wind potential in any location (Azad et al., 2014).

The two-parameter Weibull distribution is most commonly known for its high accuracy for wind speed data analysis (Zghal et al., 2011).

The Weibull PDF is given by

$$f(v) = \left(\frac{k}{c}\right) \left(\frac{v}{c}\right)^{k-1} e^{-\left(\frac{v}{c}\right)^k} \quad (4)$$

And its corresponding cumulative distributive function

$$F(v) = 1 - e^{-\left(\frac{v}{c}\right)^k} \quad (5)$$

Where c is the scale parameter and K is the shape parameter. The scale parameter indicates the wind regime at that location.

The mean and variance are respectively given by equations (6) and (7) below

$$\bar{V} = E(v) = c \Gamma\left(1 + \frac{1}{k}\right) \quad (6)$$

$$Var. (v) = c^2 \left[ \Gamma\left(1 + \frac{2}{k}\right) - \Gamma^2\left(1 + \frac{1}{k}\right) \right] \quad (7)$$

Where  $\Gamma$  is the gamma function.

There are other distributive functions used for wind analysis, however in this research analysis the Weibull distribution was used for analysis. Dikko and Yahaya, (2012) showed that for some cities in Nigeria, the Weibull Distribution Function produce better result for analysis. These cities are Gombe, Maiduguri and Yola.

### 1.3 Variation of Wind Speed with Height

The wind speed as well as the Weibull parameters varies proportionally according to the Hub height (Khoulood et al., 2016). As wind turbines can be placed at different heights, the wind speed needs to be measured at such height by using the power law (Zekai et al., 2012).

The law describes the vertical variation of wind speed as

$$V(h) = V_0 \left( \frac{h}{h_0} \right)^\alpha \quad (8)$$

Where  $V(h)$  is the wind speed at hub height  $h$ ,  $V_0$  is the wind speed at measured height and  $\alpha$  is wind shear power law exponent. The value for  $\alpha$  varies from 0.1 over the top of steep hills to 0.25 in sheltered locations. For flat coastal regions,  $\alpha$  is taken as 0.143 (1/7) which is the typical value used in most research (Youm et al., 2005).

Similarly, the Weibull parameters also varies with the height as expressed by Oyedepo et al. (2012) in equation (9).

$$C(h) = C_0 \left( \frac{h}{h_0} \right)^\alpha \quad (9)$$

Where  $C_0$  is the scale factor at the measured height  $h_0$ .

The hub height mentioned above is a distance from the turbine platform to the rotor of an entailed wind turbine and indicates how high a turbine stands above the ground, not including the length of the turbine blades.

## MATERIALS AND METHODS

The data for the analysis of this study were obtained from the weather station of Federal University of Kashere, Gombe state. The wind speed for the analysis of this study was collected up to four years (2014-2017) with the aid of an anemometer.

The wind speed was analyzed with the Weibull distribution which is explained in the equations (1) to (9). The analysis has two phases which are the seasonal and annual analysis. The major tools to be used for the analysis are graphs and bar charts.

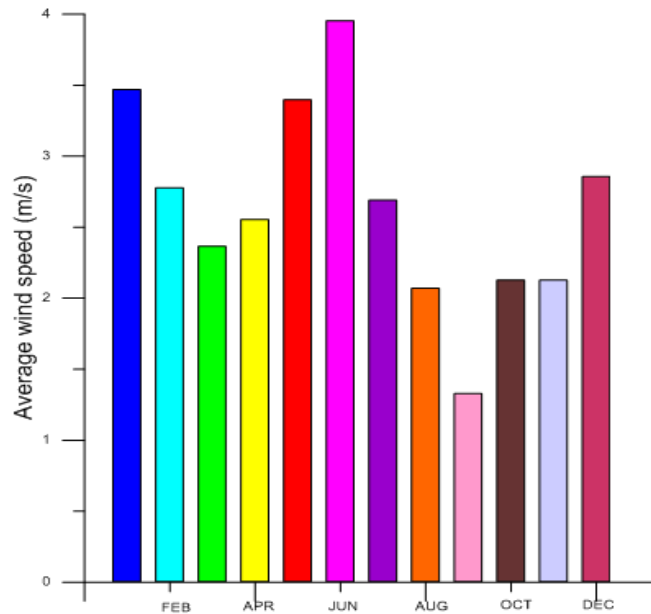
This research utilises daily average wind data measured at 2m above ground level. Data obtained were from October, 2014 to February, 2017. The data, at 2m hub height were checked thoroughly for homogeneity, outliers and missing records before being processed for the study. Spurious and missing data as well as wind gusts and cyclonic winds (wind exceeding 20m/s) were eliminated.

## RESULTS AND DISCUSSION

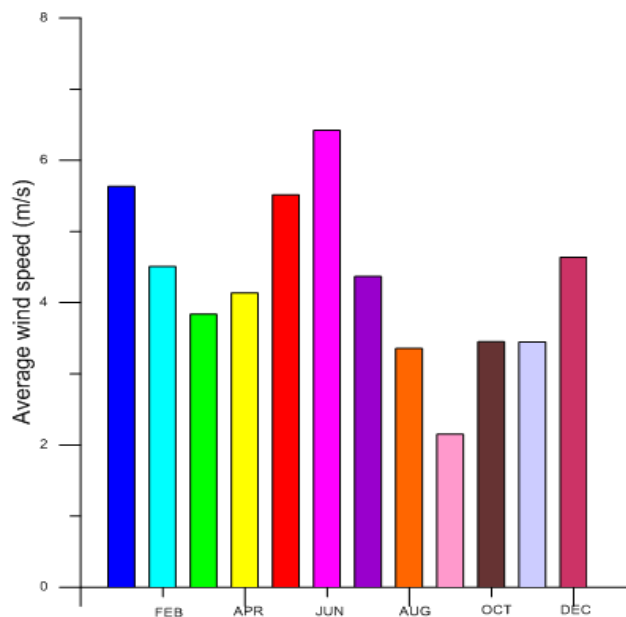
### 3.1 Analysis of Monthly Mean Wind Velocity

This study was restricted to flow of wind for normal days. The monthly averages of the filtered data, computed for heights of 2m and 60m above ground level are displayed in figure 2 and figure 3 respectively. It can be observed in figure 3 that the average wind speeds vary between 2.15m/s

and 6.42m/s with the maximum wind speed in June (Winter season) while the minimum wind speed occurred in September. It can be inferred that the wind velocity tends to be lower during the end of the rainy season.



**Figure 2.** Monthly average wind speed at 2 meters from October, 2014 to February, 2017.



**Figure 3.** Monthly average wind speed at 60 meters from October, 2014 to February, 2017.

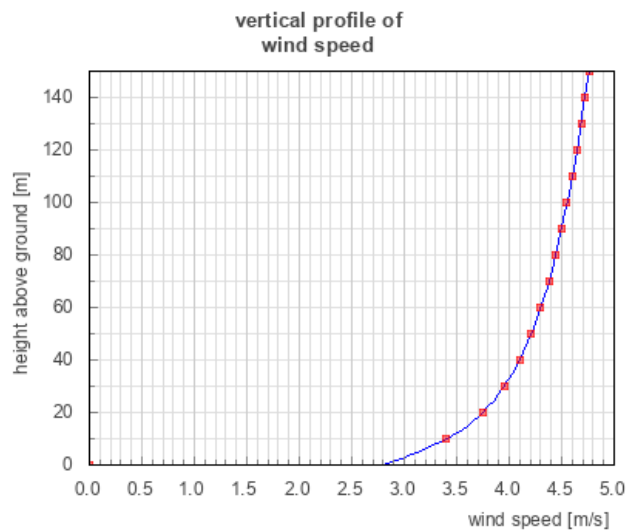
### 3.2 Wind Speed Vertical Profile

A logarithmic wind profile was used according to equation (8) to estimate the mean wind speed values at various heights (Table 1).

**Table 1:** Logarithmic wind profile of mean wind speeds and their corresponding heights.

Height above ground (m)	Wind speed (m/s)
150	4.76
140	4.72
130	4.69
120	4.65
110	4.60
100	4.55
90	4.50
80	4.44
70	4.38
60	4.30
50	4.21
40	4.10
30	3.95
20	3.75
10	3.40

The modelled average wind speed value at 60m which is good enough height for a turbine is 4.30m/s (Figure 4). This is beyond the recommended minimum of 12.6km/h (3.5m/s).



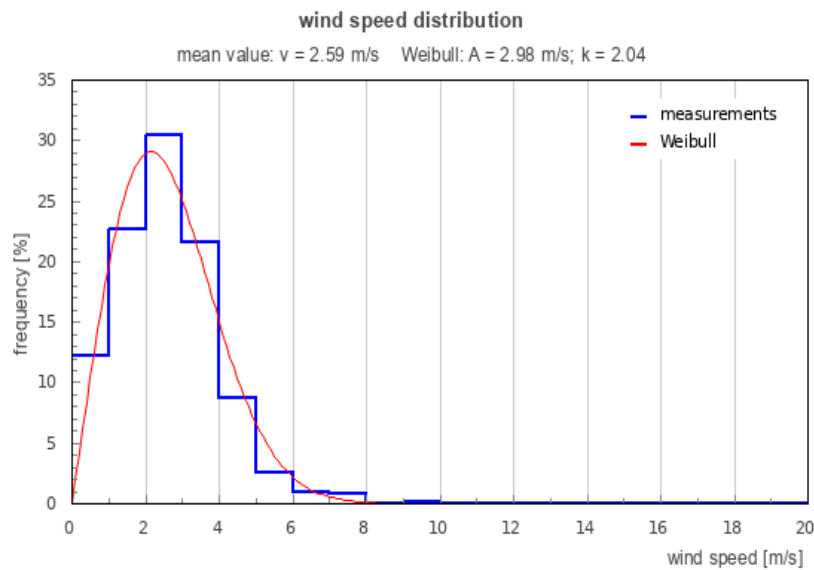
**Figure 4.** Logarithmic wind profile plot of the mean wind speeds against their corresponding heights.

### 3.3 Wind Speed Distribution

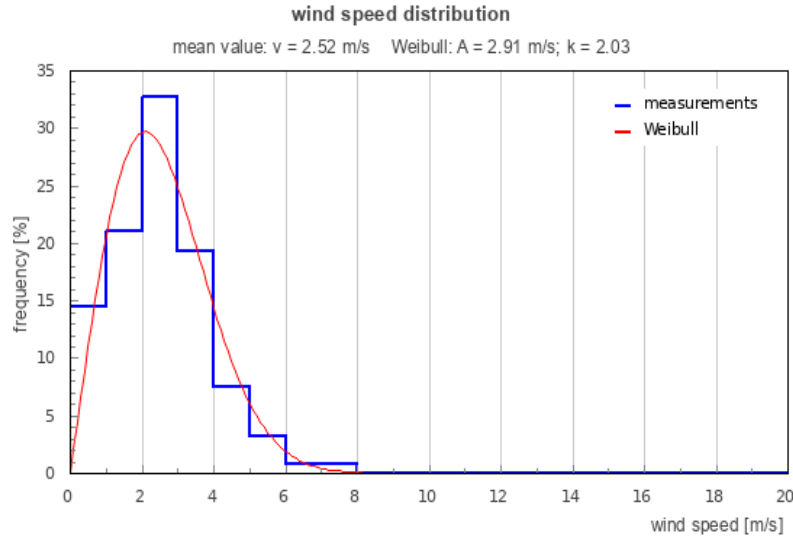
Naturally, the wind's speed constantly varies. In order to be able to predict a wind turbine's production it is necessary to know exactly how often the wind blows strongly. Normally, the wind is measured with an anemometer and the mean wind speed is recorded every day. This data was sorted into wind speed classes of 1m/s each (Table 2). The energy contained in the wind was then expressed by the frequency (Weibull) distribution as in equation (4).

**Table 2.** Wind speed frequency distribution

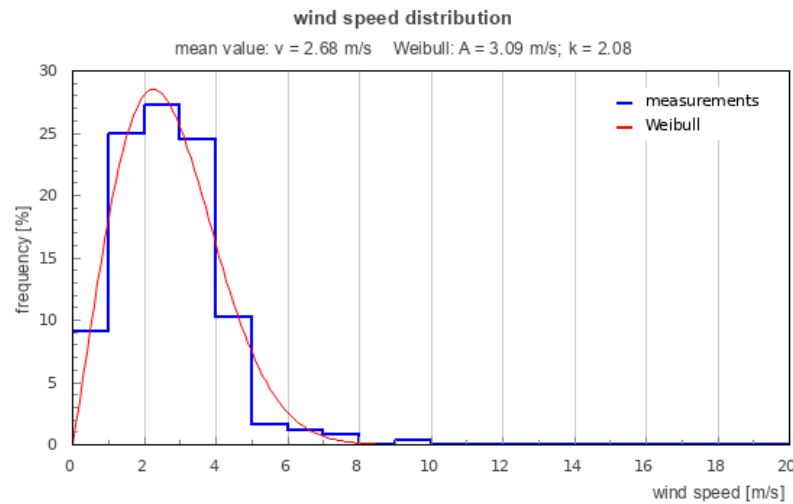
All seasons			Raining Season			Dry Season		
Range	Freq	% Freq	Range	Freq	% Freq	Range	Freq	% Freq
0-1	73.00	12.18698	0-1	50	14.45087	0-1	23	9.090909
1-2	136.00	22.70451	1-2	73	21.09827	1-2	63	24.90119
2-3	182.00	30.38397	2-3	113	32.65896	2-3	69	27.27273
3-4	129.00	21.53589	3-4	67	19.36416	3-4	62	24.50593
4-5	52.00	8.681135	4-5	26	7.514451	4-5	26	10.27668
5-6	15.00	2.504174	5-6	11	3.179191	5-6	4	1.581028
6-7	6.00	1.001669	6-7	3	0.867052	6-7	3	1.185771
7-8	5.00	0.834725	7-8	3	0.867052	7-8	2	0.790514
8-9	0.00	0	8-9	0	0	8-9	0	0
9-10	1.00	0.166945	9-10	0	0	9-10	1	0.395257



**Figure 5.** Wind speed distribution for all seasons.



**Figure 6.** Wind speed distribution for the rainy season.



**Figure 7.** Wind speed distribution for the dry season.

A is the Weibull scale parameter in m/s; a measure for the characteristic wind speed of the distribution. A is proportional to the mean wind speed. K is the Weibull form (shape) parameter. It specifies the shape of a Weibull distribution and takes on a value of between 1 and 3. A small value for K signifies very variable winds, while constant winds are characterized by a larger K. The Weibull curves peak near the average values of the wind speeds in all cases. The similarity of the trends shows a good representation given by the Weibull model when compared to the actual data.

All through the studied years and seasons the wind speed distribution showed significant stability as seen from the (above 2) K-values (Figure 5 to 7). Nevertheless, the dry season has the highest K-value of 2.08 signifying more stable winds during the season (Figure 7).

## CONCLUSION

Based on the interpretation of wind speed data, the wind speed for rainy season in the results showed that through the studied years, from 2014-2017, which was restricted to flow of wind for normal days, the monthly averages showed significant stability as observed from their K-values. It also showed that the average wind speed of 4.30m/s with the maximum wind speed in June (winter season) and the minimum wind speed occurring in the end of the rainy season, suggesting stable wind during the season.

The main conclusions drawn from this project are as follows:

- The University campus environment shows good wind energy potential.
- Part of the energy requirements for the University can potentially be obtained from the wind throughout the year.
- The average wind speed of 4.30m/s is beyond the recommended minimum value of 3.5m/s suggesting that it is very good to start a turbine.
- The K-value of 2.08 is good since it falls beyond 69% of the required maximum.

## REFERENCES

- [1] Abdeen, M. O. (2011). Energy and environment: applications and sustainable development. *British journal of environment and climate change*, 1(4): 118 -158.
- [2] Abdulkarim, A., Abdelkader D. J., Falade A. J and Adediran Y. A. (2017). Statistical analysis of wind speed for electrical power generation in some selected sites in northern Nigeria. *Nigerian journal of technology*. 36(4) 1249-1257.
- [3] Alam, M., Shafiqur, R., Josua, M. and Luai, M. (2011). Wind speed and power characteristics at different heights for a wind data collection tower in Saudi Arabia. *Journal of world renewable energy congress*, 8 – 13.
- [4] Azad, A. K., Rasul, M. G and Yusaf, T. (2014). Statistical diagnosis of the best Weibull method for wind power assessment for agricultural applications. *Energies*, 7: 3056-3085.
- [5] Dikko, I. and Yahaya D. B. (2012). Evaluation of wind power density in Gombe, Yola and Maiduguri, North Eastern Nigeria. *Journal of research in peace, Gender and development*. 2(5), 115-122.
- [6] Khoulood, B., Mahieddine, A. and Rabah, L. (2016). Assessment and analysis of wind energy generation and power control wind turbines system. *Rev. Sci. Technol., Synthese* 32: 147-162.
- [7] Mark, Z. J., Mark, A. D., Mary, A. C. and Brain, V. M. (2018). Matching demand and supply at low cost in 139 countries among 20 world regions with 100% intermittent wind, water and sunlight (WWS) for all purposes. *An international journal of renewable energy*, 0960 – 1481.
- [8] Ohunakin, O. S. (2011). Assessment of wind energy resources for electricity generation using WECS in North-Central region, Nigeria. *Renewable and Sustainable Energy Reviews*. 15: 1968-1976.
- [9] Oluseyi, O. A., Richard, O. F., James, K., Julius, M. N., David, O.O., and Adekunle A. B. (2014). Wind energy study and energy cost of wind electricity generation in Nigeria: past and recent results and a case study for south west Nigeria. *Energies*, 7: 8508 – 8534.

- [10] Oyedepo, S. O., Adaramola, M. S., and Paul, S. S. (2012). Analysis of wind speed data and wind energy potential in three selected locations in south–east Nigeria. *International Journal of Energy and Environmental Engineering*, 3(7): 1–11.
- [11] Ulan, D. (2013) Analysis of wind power generation with application of wind of wind tunnel attachment. Dissertations and theses at University of Northern Iowa (UNI), 4.
- [12] Youm, I., Sarr, J., Sall, M., Ndiaye, A., and Nane, M. M. (2005). Analysis of wind data and wind energy potential along the northern coast of Senegal. *Renewable and Sustainable Energy Reviews*, 8: 95–108.
- [13] Zekai S, Abdusselam, A. and Tarkan, E. (2012). Wind velocity vertical extrapolation by extended power law. *Advances in meteorology*, 178623.
- [14] Zghal, W., Kchaw, G. and Kantchev, H., (2011). Determination of recoverable wind energy for electricity generation using wind energy conversion system in Tunisia. *International Journal of Engineering Science and Technology*, 3(5): 83-92.



## **MECHANICAL AND MORPHOLOGICAL PROPERTIES OF DIFFERENT NATURAL FIBRE REINFORCED POLYLACTIC ACID COMPOSITES: A REVIEW**

S.F.K. Sherwani<sup>1</sup>, S.M. Sapuan<sup>1,2</sup>, Z. Ieman<sup>1,2</sup>, E.S. Zainudin<sup>1,2</sup> and A. Khalina<sup>2</sup>

<sup>1</sup>Advanced Engineering Materials and Composites Research Centre, Department of Mechanical and Manufacturing Engineering, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

<sup>2</sup>Institute of Tropical Forestry and Forest Products, Universiti Putra Malaysia, 43400 UPM Serdang, Selangor, Malaysia

Author: faisalsherwani786@gmail.com Corresponding authors: \*sapuan@upm.edu.my

### **ABSTRACT**

The determination of mechanical and morphological properties of polylactic acid (PLA) reinforced with different natural fibre were studied in this paper. Tensile, impact, percentage elongation, flexural properties were found out of various composite material like Nettle fibre reinforced PLA, Grewia optiva fibre reinforced PLA, sisal fibre reinforced PLA, composite foams of PLA/bagasse fibre, PLA/flax composites, PLA/ cellulosic natural fibres, Wood fibre reinforced PLA composites. The value of tensile strength was found to be enhanced when compared neat PLA with natural fibre blend PLA. Since PLA is brittle, its nature also changes when natural fibre is applied and the percentage elongations increases as well. Up to 30% improvement in impact strength also noted in previous experiment on different PLA composites. Morphological analysis reveals strong adhesion rates between natural fibre and matrix PLA.

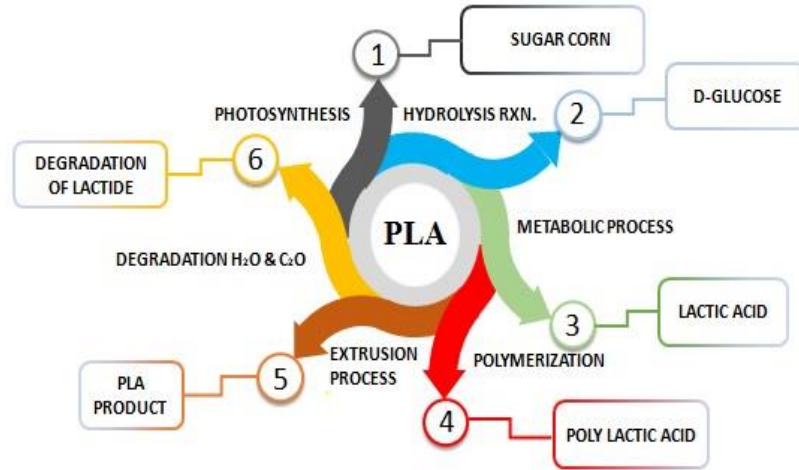
**Keywords:** Polylactic acid, Natural fibre reinforced, Mechanical properties, Lifecycle of PLA.

### **INTRODUCTION**

As pollution caused by non-degradable material like synthetic fibres has led to research on environmentally friendly material production. In finding the solution of such a problem, researcher switched from synthetic fibres (non-degradable material) to natural fibres (biodegradable material). The main advantages of using natural fibres are renewability, easily availability, biodegradability, non-toxic, cheap, low specific gravity, high toughness and good strength[1]. By the using biodegradable material the effect of environmental pollution can also be reduced.

Polylactic acid (PLA) polymers have been commercially attempted to incorporate in the field of biodegradable materials since the last decay. PLA is obtained from the fermentation processes of natural agricultural raw material. This process initially gives lactic acid which has a cyclic dilactone, lactide, ring open structures. The polymerization of lactic acid is known as polylactic acid. It is a renewable polymer that has better stability in temperature and less residual material. The thermal stability can be enhanced by using different synthetic or natural fibres as reinforcing material. PLA is brittle in nature. The mechanical properties mainly percent elongation and

impact can be improved by adding plasticizers into PLA. The decomposition takes place by hydrolysis of lactic acid, which is metabolized by micro-organisms into H<sub>2</sub>O and CO<sub>2</sub>. Biodegradation occurs within two weeks by composting with other biomass, and the material has completely disappeared within 3–4 weeks. Fig.1 shows lifecycle of PLA.



**Figure 1.** Lifecycle of Poly(lactic acid) (current study)

## MATERIALS AND DISCUSSIONS

**Table 1.** Mechanical and Morphological Properties of Natural Fiber reinforced polylactic acid composites

AUTHORS	NATURAL FIBRES	TEST	DESCRIPTIONS
Bajpai et al.,[2]	Nettle, Grewia optiva and sisal fibres	Tensile strength	<ul style="list-style-type: none"> <li>Only PLA - 39.18 MPa</li> <li>PLA/sisal- 80.6MPa</li> <li>PLA/nettle- 50.32MPa</li> <li>PLA/ G. Optiva- 73.9MPa</li> <li>Young modulus of pure PLA-3.02GPa</li> <li>Tensile strength of biocomposites is not good because of poor adhesion between fibre and matrix.</li> </ul>
		% elongation	<ul style="list-style-type: none"> <li>PLA- 3.98% and polypropylene (PP) –more than 25% because it is more ductile than PLA.</li> <li>PLA/G. Optiva- 5.74%; PLA/nettle- 4.63%; PLA/sisal-3.42%</li> <li>These start propagating very rapidly in the matrix as soon as cracks are started and induce bulk failure as shear stress is localized at the interface of the fiber – matrix.</li> </ul>

AUTHORS	NATURAL FIBRES	TEST	DESCRIPTIONS
			<ul style="list-style-type: none"> <li>The natural fibres are supposed to behave as hurdles to delay the composite fracture process, thus reducing the risk of sudden composite failure.</li> </ul>
		SEM	<ul style="list-style-type: none"> <li>During tensile test, SEM micrographs show that the bio-composite has matrix splitting, fibre fracturing and fibre pullout.</li> <li>Tensile properties of composite depend upon adhesion level, bonding character and fibre pullout.</li> <li>Different surface roughness visible for different natural fibres. Sisal fibres shows good wetting with PLA than G. Optiva fibres as well as Nettle fibre.</li> </ul>
		Flexural test	<ul style="list-style-type: none"> <li>The value of flexural strength is 249.8MPa and 1044MPa for PLA/sisal composite and neat PLA.</li> <li>The value of flexural modulus is 9.75GPa and 3.79GPa for PLA/sisal composite and neat PLA.</li> <li>The value of flexural strength is 202MPa and 164.8MPa for PLA/G. Optiva and PLA/nettle composite.</li> <li>The value of flexural modulus is 10.97GPa and 7.88GPa for PLA/G. Optiva and PLA/nettle composite.</li> <li>The flexural properties of bio-composites are also depending upon the interfacial characteristics of the fibres and the matrix.</li> </ul>
		Charpy impact strength	<ul style="list-style-type: none"> <li>The impact strength- PLA/sisal and PLA/G. optiva composite increases while the impact strength of PLA/nettle composite decreases.</li> <li>Because of brittle nature of PLA matrix, the composite specimens were broken into two parts fully during charpy test.</li> <li>Impact strength decreases because the stress were concentrated over a region on adding natural fibres into PLA matrix which required low energy for creating crack.</li> <li>The value of impact strength of PLA/nettle composite is less than neat PLA because of</li> </ul>

AUTHORS	NATURAL FIBRES	TEST	DESCRIPTIONS
			<p>developing stress concentration area around the natural bundles which required less energy to create cracks.</p> <ul style="list-style-type: none"> <li>Impact strength of PLA / carbon fibre composites improved by up to 30 percent fibre volume fraction.</li> </ul>
Nampitch[3]	Composite foams of PLA/bagasse fiber (Thailand)	Tensile strength	<ul style="list-style-type: none"> <li>Neat PLA- 25.63MPa</li> <li>Composite 7wt%- 45.27MPa</li> <li>Addition of bagasse fibre (till 7 %) increase tensile strength because of the chemical interaction between the ester group of PLA and the OH group.</li> <li>After 7% its strength decreases, due to the fibres weakening the composites.</li> </ul>
		% elongation	<ul style="list-style-type: none"> <li>After 7% fibre, further adding show decrease in elongation because of the fibre's natural effect of reducing mobility in composites, making the material stiffer and harder.</li> </ul>
		Impact strength	<ul style="list-style-type: none"> <li>Bagasse fibres with high content could be aggregated because of fibre-fibre interaction, which causes the mechanical properties to worsen.</li> <li>Exhibit 15 and 20%wt bagasse fibres minimum mechanical properties,</li> <li>10% wt bagasse fibres enhance optimum mechanical properties.</li> <li>As on addition of natural fibre, the mobility of polymer chains reduces because of which absorbing energy ability decrease in composite. That's why impact strength decrease.</li> </ul>
		SEM	<ul style="list-style-type: none"> <li>Shows neat PLA showed a smooth surface and smooth bubble in the middle of the specimen</li> <li>composite showed a rougher surface and bubbles that looked like cracks increased fibre content in the matrix showed an even rougher surface with the bubble likely more deformed</li> <li>This phenomenon could be due to the bubble dispersion in the PLA sample where</li> </ul>

AUTHORS	NATURAL FIBRES	TEST	DESCRIPTIONS
			they could easily move and coalesce without obstacles, while in the composite sample they could not.
K.Oksman[4]	PLA/flax composites	Tensile stress	<ul style="list-style-type: none"> <li>• PLA only - 50MPa and a modulus of 3.4GPa.</li> <li>• Adding of flax fibres into PLA will decreases the tensile strength of whole composite, which shows weak adhesion between fibres and matrix. The stress does not pass from the matrix to the stronger fibres.</li> <li>• The addition of flax fibre increases the tensile modulus; the tensile modulus depends on fibre orientation.</li> </ul>
Yicheng Du[5]	PLA/cellulosic natural fibers	Tensile strength	<ul style="list-style-type: none"> <li>• There was a variation in tensile modulus and strength when fibre loading changes. After 50% of fibre loading, the dry spots or a void increases because of which tensile strength decreases.</li> </ul>
M.S.Huda[6]	Wood fiber (WF) reinforced PLA composites	Flexural strength and modulus	<ul style="list-style-type: none"> <li>• Comparing flexural strength and modulus of Neat PLA - 98.8MPa and 3.3GPa and PLA/WF (60 wt %/40 wt %) composite - 114.3MPa and 10.2GPa</li> </ul>
		Tensile strength (MPa)  Tensile Modulus (GPa)	<ul style="list-style-type: none"> <li>• Neat PLA <math>62.8 \pm 4.9</math> and <math>2.7 \pm 0.4</math></li> <li>• Tensile strength value on adding WF increases till 30% loading and then decreases.</li> <li>• Tensile strength of Wood fibre (WF) reinforced PLA composites depends upon the orientation of wood fibre. Well alignment shows higher tensile strength.</li> <li>• Up to 30%wt of wood fibre loading, the tensile strength increases. This was because of increasing wetting of fibres with matrix resin.</li> <li>• If the wetting of natural fibre is not appropriate strength become week and composite can fail also.</li> <li>• The value of tensile modulus of composite increases as the quantity of wood fibre increases.</li> </ul>

AUTHORS	NATURAL FIBRES	TEST	DESCRIPTIONS
			<ul style="list-style-type: none"> <li>• The modulus of PLA increases proportionately as the amount of WFs in the composite increases.</li> <li>• Raising the tensile module is also depends upon the compatible with the mixture law, which stipulates that the matrix is reinforced by fibres capable of transmitting tension through the fibre-matrix interface.</li> </ul>
M. Chalid[7]	Ijuk Fiber / PLA Biocomposites	Tensile strength	<ul style="list-style-type: none"> <li>• Addition of ijuk fibre would enhance both young's modulus and tensile strength.</li> <li>• Alkaline treatment increases the compatibility of ijuk and PLA.</li> <li>• Low surface adhesion between fibre and matrix without treatment. Some small gaps were also visible.</li> <li>• Elastic modulus and tensile strength decrease after 20% of ijuk fibre volume fraction, this is because of voids or fibres pull-out in the biocomposite.</li> <li>• Uniform distribution of ijuk fibre by stirring can solved these above two problems.</li> </ul>

## RESULTS AND CONCLUSION

Mechanical Properties of PLA were improved on addition of various natural fibres. From the table we can summarized that, As PLA is brittle, but on loading of natural fibre it shows ductile nature, because of the adhesion between fibre and PLA matrix, the tensile property of PLA composite has been improved. Morphological studies show the smooth surface on addition of natural fiber but at certain limit it was mainly 40% of natural fibre loading.

## ACKNOWLEDGEMENTS

The authors would like to thank Universiti Putra Malaysia and Ministry of Education, Malaysia for the financial support through the Special Graduate Research Fellowship (SGRF) scholarship, Vote No.: 5542500. The authors are grateful to Dr. Ahmed Ilyas Rushdan for guidance throughout the review.

## REFERENCES

- [1] A. S. Singhaa and V. K. Thakura, "Fabrication and study of lignocellulosic hibiscus sabdariffa fiber reinforced polymer composites," *BioResources*, vol. 3, no. 4, pp. 1173–1186, 2008.
- [2] P. K. Bajpai, I. Singh, and J. Madaan, "Comparative studies of mechanical and morphological properties of polylactic acid and polypropylene based natural fiber composites," *J. Reinf. Plast. Compos.*, vol. 31, no. 24, pp. 1712–1724, 2012.
- [3] T. Nampitch, C. Wiphanurat, T. Kaisone, and P. Hanthanon, "Mechanical and Morphological Properties of Poly(Lactic Acid)/Bagasse Fiber Composite Foams," *Appl. Mech. Mater.*, vol. 851, pp. 31–36, 2016.
- [4] K. Oksman, M. Skrifvars, and J. F. Selin, "Natural fibres as reinforcement in polylactic acid (PLA) composites," *Compos. Sci. Technol.*, vol. 63, no. 9, pp. 1317–1324, 2003.
- [5] Y. Du, T. Wu, N. Yan, M. T. Kortschot, and R. Farnood, "Fabrication and characterization of fully biodegradable natural fiber-reinforced poly(lactic acid) composites," *Compos. Part B Eng.*, vol. 56, pp. 717–723, 2014.
- [6] M. S. Huda, L. T. Drzal, M. Misra, and A. K. Mohanty, "Wood-fiber-reinforced poly(lactic acid) composites: Evaluation of the physicomechanical and morphological properties," *J. Appl. Polym. Sci.*, vol. 102, no. 5, pp. 4856–4869, 2006.
- [7] M. Chalid and I. Prabowo, "The Effects of Alkalization to the Mechanical Properties of the Ijuk Fiber Reinforced PLA Biocomposites," *Int. J. Chem. Mol. Nucl. Mater. Metall. Eng.*, vol. 9, no. 2, pp. 342–346, 2015.

## **A REVIEW ON GREEN CLEANING DURING AND POST COVID-19 PANDEMIC**

A. Kamaruddin<sup>1</sup>, \*N.N. Zainol<sup>1</sup>, and M. A. Sulaiman<sup>1</sup>

<sup>1</sup>Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA (UiTM)  
40450 Shah Alam, Selangor, Malaysia.

\*Email: nadiyahzainol@uitm.edu.my  
Phone: +60107051409

### **ABSTRACT**

The virus that causes COVID-19 spreads primarily through droplets generated when an infected person coughs, sneezes, or speaks. Someone can also be infected by touching a contaminated surface, then touching their eyes, nose, or mouth before washing their hands. People are advised to clean hands regularly and thoroughly, and avoid touching eyes, mouth, and nose to keep safe from the virus. Cleaning has never been a greater concern than it is today since the COVID-19 pandemic has spread throughout the world. However, methanol, ethanol, and chlorine-based are often used in cleaning and disinfecting products to kill the virus on surfaces. These chemicals called volatile organic compounds (VOCs) which are found in commonly used conventional cleaning products. The excessive usage of these products will cause indoor air pollution and other numerous health implications which are very harmful to the building occupants and especially for the clean workers and the people with health conditions. Therefore, it is important to implement a green cleaning programme to reduce the issue of environmental health impact. This paper aims to discuss the benefits green cleaning and how to maintain cleanliness in a green way and without damaging health. This paper is anticipated to be significantly beneficial and can be further used as a piece of information for facilities management and the people.

**Keywords:** Green cleaning, COVID-19, Problems and hazard

### **INTRODUCTION**

The COVID-19 pandemic is changing the way of peoples' lives in various ways. People are no longer only worried about the visible dirt, instead they are guarding against the invisible germs what is more a highly contagious virus. In the absence of a vaccine or effective antiviral treatments, which most likely not be available in the near future, several countries imposed strict lockdown measures to curb the spread of the disease. In Malaysia, the local governments spent more than three times their approved budget on community policing, hygiene(cleaning) and care services [1]. One of the most effective ways in preventing the spread of harmful microbes and to reduce the potential for COVID-19 virus contamination are to clean and disinfect [2–4] in the everyday life. Cleaning is an important first step to the process because it physically removes soil, organic matter, and many germs from the surface. Those that are frequently touched in all areas should be identified for priority disinfection and should be regularly cleaned



[2,3] these include but are not limited to such as door and window handles, kitchen and food preparation areas, counter tops, bathroom surfaces, toilets and taps, touchscreen personal devices, personal computer keyboards, and work surfaces. The COVID-19 pandemic has led to major changes for homes and business, including more frequent use of chemicals and disinfectants. While they do to help, some can be dangerous to human health and environment [5]. These cleaning products that are often used and available in most markets contained massive amounts of harsh chemicals. Abrasive chemicals can be highly efficient cleaners, but they also have significant drawbacks. The challenge is to fight the spread of the virus and at the same time, to maintain a green hospitality with “eco-friendly”, “green” or “sustainable” cleaning and disinfecting. The objective of this paper is to review the potential impact on the COVID-19 pandemic on the green cleaning. Therefore, it is important to grasp the knowledge and have an understanding on how the conventional cleaning impacts negatively towards the people and the surrounding before adopting green cleaning process.

## **LITERATURE REVIEW**

### **Cleaning during COVID-19**

During the COVID-19, many institution buildings are closed to all and since the shutdown, cleaning has been focused on the floors that are occupied especially in a high- touch surfaces area. The demands for hand sanitizing and deep-cleaning services are rising around the globe in light of the COVID-19 pandemic. In the United Kingdom, a number of cleaning companies services statewide and locally have seen an increase in requests for additional services as people are being reminded to constantly clean and disinfect all commonly-used areas, offices and facilities to prevent the COVID-19 from spreading [6]. Malaysia has numbers of janitors and domestic workers who are fighting to “flatten the curve” of the COVID-19. As the COVID-19 began sweeping across the Malaysia, demand for cleaning and disinfecting are also skyrocketed. There are increasing numbers of organizations and people that are seeking for cleaning and disinfecting products which capable in eliminating COVID-19. According to data published by market research firm Kantar, U.K., hand sanitizer sales saw a year-on-year increase of 225% in February [7]. Analysts found that sales in Malaysia of hand sanitizers hit almost 1 million Malaysian ringgit during the week ending January 26 which makes it higher than the amount the country spends on the product in an average week [7]. According to Chemical Company of Malaysia Bhd (CCM), the demand for some chemical products amid the COVID-19 pandemic is rising [8]. The government has issued the guidelines and Standard Operating Procedures (SOP) for approved manufacturing companies to comply with during the Movement Control of Order (MCO). For instance, the management of healthcare facilities has issued their cleaning personnel to perform a cleaning and disinfection process the before operation begins in accordance with the guidelines set by the Ministry of Health Malaysia. Furthermore, the sanitation and cleaning process should be performed three times a day especially in common spaces such as lobbies, elevators, cafeterias, toilets, meeting rooms, prayer rooms and etc. [9]. Cleaning is an important first step because it physically removes dirt, organic matter and most germs from surfaces. All surfaces must be thoroughly cleaned before disinfection as this ensures that germs are not hidden from the disinfectant when it is applied [10]. Meanwhile, disinfection is the process that destroys most disease-causing germs that remain on surfaces [11]. This process does not necessarily clean dirty surfaces or remove germs, but by killing germs on a surface after cleaning, it can further

lower the risk of spreading infection. Frequent cleaning and disinfection help to prevent the spread of germs that may cause illness, especially COVID-19 during these times. A routinely cleaning and disinfecting should be done for frequently touched surfaces or shared surfaces and items. Next, cleaning and disinfecting should be done more often when illness levels have increased. Lastly, immediately to clean and disinfect when surfaces are contaminated with blood or body fluids.

In the light of these facts, it arises on the issues in ways to reducing the risk for everyone while maintaining a clean environment. In addition, on the issue of whether the cleaning and disinfecting products are being safe to use for the people and the environment in the long term as the need for cleaning practice must be preserved beyond the easing of restrictions in Malaysia.

### **Problems and Hazard of Conventional Cleaning**

Concurrently, the front liners are risking their lives in fighting this global pandemic especially the cleaning workers. These cleaning workers work every day to properly and safely use cleaning products that help keep the environment healthy. This is very harmful for cleaning workers who face risks for the effort of overcoming COVID-19 pandemic where they manage harsh chemicals, carry loads and high possibly to come into contact with infectious waste. Now, these workers are potentially exposed with the COVID-19.

Certainly, the most common effective cleaning and disinfecting products are alcohol and chlorine-based (bleach type) ones. Other common active ingredients found in the U.S Centers for Disease Control and Prevention (CDC) and the Environmental Protection Agency (EPA) recommended disinfecting cleaning products that are effective to kill many viruses and bacteria are, Ethanol alcohol (60%-90%); Hydrogen peroxide; Isopropyl alcohol (60%-90%); Quaternary Ammonium; and Sodium hypochlorite [6,7]. In spite of that, a study found that [8], these are actually products that should be avoided since the sodium hypochlorite-based cleaners are harmful to the environment, but also to the skin and respiratory system. Furthermore, the quaternary ammonium compounds or quats are very not much recommended. This is because, quats can be toxic if inhaled and are also known to cause birth defects and are toxic to marine life if they enter waterways [9].

In addition, a virex, is a cleaning agent that is also being used against the covid-19 which can also cause rashes and burns. These conventional cleaning products contain volatile substances that are capable of causing irritation and toxicity where ventilation is very much needed when using these products. According to the handling of cleaning and disinfecting guidelines prepared by the World Health Organizations (WHO), the cleaning and disinfectant solutions should always be prepared in well-ventilated areas [2], keep away from vulnerable populations such as children, pregnant women, the elderly and people with other pre-existing health conditions or sensitivities away during the application of the products until it is dry and there is no odour, and it is necessary to wash hands right after using any cleaning or disinfectants. This shows that the toxic effect of chemicals released from the cleaning and disinfectant products can lead to eye and skin irritation, bronchospasm due to inhalation, and potentially gastrointestinal effects such as nausea and vomiting [12].

A growing body of evidence suggests that the ingredients of many cleaning and disinfecting products and process may have unintended negative impacts on human health and the environment. The exposures to cleaning chemicals can cause dermatitis, endocrine and neurological effects, cancer, asthma, and other respiratory disorders [13,14]. Cleaning chemicals may contribute to the pollution of outdoor air and water supplies, damage to ecosystems,

bioaccumulation in animals and plants, and ozone depletion [14]. This has shown that conventional cleaning has contributed to emit volatile organic compounds (VOCs) and result in the presence of indoor air contaminants and health impairment. It should not be ignored that increasing use of any conventional cleaning chemical will inevitably have an environmental impact. Therefore, it is very important to go into in-depth about a proper cleaning aspect to be implied for buildings in general. This is the point where eco-friendly cleaning or also known as green cleaning takes place.

### **Concepts of Green Cleaning**

The principle that effective cleaning with high-quality detergents across all-non critical touch surfaces is as effective as the widespread systematic or abusive use of cleaning and disinfectants is known as “Justified Disinfection” [15]. A cleaning and disinfecting should only be used when and where it is useful and relevant. One commercial cleaning manufacturer, InnuScience has emphasised that over-relying on cleaning and disinfectants risks a negative impact on the environment rather on effective cleaning using high performing detergents [15]. Since the conventional cleaning products and process represents a huge problem for people and environmental health, this can be achieved in the form of selecting products which do not cause harm to the environment. Concerned about the adverse human and environmental effects of traditional cleaning practices, many organizations nowadays have been increasingly adopting green cleaning or sustainable cleaning practices. Green cleaning is different from conventional cleaning. A green and effective cleaning process can be a critical component in helping the building to function with a greater operational and financial efficiency.

Green cleaning is a cleaning to protect health without harming the environment [16], or “the efficacy of infection prevention and control towards effective products with the fewest adverse effects on human health and the environment”, or “maintaining and improving cleanliness and supporting infection control while protecting workers and the environment from the risks posed by cleaning materials and processes” [17,18]. Basically, green cleaning refers to the usage of environmentally friendly cleaning procedures and products which are intended to preserve the quality of the environment (reducing use of chemicals, water and energy) and human health. Unlike conventional cleaning product and process that are known to contribute to health problems such as eye, skin and respiratory irritation as well as asthma and other allergic reactions, which can lead to occupant complaints and hurt attendance and productivity. Therefore, green cleaning is important since one of the crucial factors is the potential harm that can be caused by traditional cleaning chemicals. Green cleaning is one of the sustainability integrations [19– 21] where it minimizes the impact of cleaning on people and the environment but more importantly, it is a process, not a mere product. Green cleaning definitions incorporate environment, economy and social aspect as highlighted in table 1.

**Table 1.** Definitions of green cleaning

Definition(s)	Defined by	Aspects
A cleaning to protect human health without harming the environment, using processes and benign products while ensuring cleaning is conducted for the health of building occupants janitorial cleaning staff and the environment.	[22]	Environment, Social (human health), Economy (benign products)
A promising approach to environmental cleaning that aims at reducing harm to human health and the environment while maintaining or improving the hygiene of the environment.	[15]	Environment (improve hygiene), Social (human health)
A cleaning to protect health without harming the environment and it is about effective cleaning to create healthier buildings and at the same time reduce environmental impacts.	[23]	Environment, Social (protect health)
The elimination of toxic cleaning products in favour of substitutes that are less harmful to human health and the environment, or even harmless, as well as can reduce maintenance costs, protect the environment, safeguard the health of workers and building occupants, and improve indoor air quality.	[24]	Environmental, Economy (efficiency of resources use), Social (human wellbeing)

In Malaysia, research and practice of green cleaning is still in its infancy. A growing body of evidence has documented that comprehensive green cleaning programs have led to significant savings on energy, water, chemicals and waste. Not only that, green cleaning programs also interests in reducing illness and injuries to custodial staff as well as workers' compensation costs. However, to this day, there are no specific guidelines or specific regulations for green cleaning in Malaysia [18,20,25]. In addition, the Green Building Index (GBI), is the Malaysian environmental rating system that aims to evaluate the environmental design and performance for new and existing buildings in Malaysia. This rating tool has yet to state any requirement specifically for green cleaning in their assessment tool. Thus, it is not only relevant and significant to discuss and explore the benefits of implementing green cleaning, but also important to understand the concept of green cleaning implementation and how green cleaning can contribute to achieving a better building performance on post COVID-19.

### **Benefits of Green Cleaning**

The goal of green cleaning is to protect the health of building occupants, visitors and cleaning personnel, as well as reducing polluting effects on natural resources [29]. "Green" and

“Sustainability” are closely related. The concept of sustainable green cleaning has evolved essentially is the use of green cleaning tools, cleaning solutions and equipment [30]. Considering this, that make facilities greener and healthier, have reduced impact on the environment, promote and ensure environmental, social and economic benefits and reduce the use of natural resources of all kinds. Thus, the sustainability of a building is directly influenced by green cleaning.

**Table 2.** Benefits of green cleaning implementation

Aspects	Benefits	Authors
Social	1) Provide a safe and healthy environment to occupants and janitors 2) Improve occupants’ and janitor’s performance and productivity 3) Enhance organizations’ image 4) Reduce absenteeism and sick leave	[18,19,24–27]
Environmental	1) Improve indoor air quality (IAQ) 2) Reduce waste 3) Reduce environmental pollution from chemical use 4) Reduce the excessive use of resources such as energy, water and chemical	[18,20,26,28]
Economic	1) Reduce operating cost due to the reduction of energy consumption, water and cleaning product usage 2) Reduce medical expenses due to higher rates of injury and illness. 3) Increase the value of the building and rental income. 4) Reduce cost to purchase cleaning product due to efficient usage. 5) Reduce the cost of repairing or replacement in long term	[18,20,24,25]

According to the table 2, many researchers have agreed on adopting green cleaning will have a positive impact on the economy, society and environment primarily in this time of pandemic crisis. Green cleaning means more than using “green” products [21] and it is not a merely using of the products. Instead, a thorough process and equipment also should be included in the green cleaning programme. A study conducted by [16] appears that only 1% out of 16% respondents perceives green cleaning as a practice of selecting and using appropriate cleaning products, while omitting other important aspects of green cleaning such as operational optimization and building design. This is also supported by a study that with proper cleaning and disinfecting surroundings with the commonly touched objects helps prevent the spread of all contagious diseases, including COVID-19 [29]. A proper usage of these products should be followed carefully in order to successfully cleaning an area in a green way. The use of green cleaning products without guidelines or a proper procedure causes negative consequences such as waste of products and can damage the surface which negates the aim of the green cleaning. This is supported by studies

that unskilled cleaning workers are one of the results from the mishandling of cleaning chemicals [25,26]. A successful green cleaning process should consider strategies, sustainability practices, green cleaning equipment, a commitment to indoor air quality, green cleaning chemicals and so forth that demonstrate a solid commitment to a green cleaning programme [30].

Since COVID-19 is highly transmissible and can spread quickly through a community, it is important to increase the amount of times to clean and disinfect household surfaces in order to decrease transmission in every safe way possible. This is because, according to a study from National Institutes of Health, scientists found that the COVID-19 is stable for several hours to days in aerosols and on surfaces. The results from the study suggest that people may acquire the virus through the air and after touching contaminated objects [31]. Therefore, preventive measures should be taken seriously to prevent the COVID-19 to spread in the households. For example, after returning home from outing, or after leaving a public space and workplace or even after caring for someone sick, wash hands with soap and water especially before touching face and eating or preparing food [32]. Use a hand sanitizer if there is unavailability of soap and water. After unpacking the groceries, wash hands again and clean kitchen surfaces such as countertops, any handles or switches. Nevertheless, more frequent cleaning and disinfection may be required based on level of use. For example, surfaces that are frequently touched by multiple people, such as door handles, desks, phones, light switches, and faucets should be cleaned and disinfected daily. Furthermore, certain surfaces and objects in public spaces, such as shopping carts and point of sale keypads, should be cleaned and disinfected before each use. It is important now to make sure cleaning and hygiene precautions are not just being done but being carried out correctly to ensure effectiveness. In addition, training that covers the cleaning and disinfection and the proper use of protective equipment is vital since using improper methods or products can spread the microorganisms that are responsible for infections [33]. Proper selection and use of green cleaning products can help safeguard the health and safety of building occupants and the planet. Proper cleaning and disinfection are the next primary layer of defense from COVID-19.

### **Post COVID-19**

Undeniably, COVID-19 has transformed the lives of humans everywhere. People are now much more aware on the importance of cleaning and of the environment in which it translates into the way where their cleaning products should not contribute to harming the environment. By implementing the best practices of green cleaning into daily routines, a habit that help reducing the COVID-19 to spread or other seasonal diseases as people look to the future. It is also essential for the people to change the ways when using public spaces to work, live and play. More precautions are taken by people and organizations where the high use surfaces are cleaned more frequently especially on other surfaces in heavily trafficked areas. The significant behavioral changes during the ease of restrictions in Malaysia, the people continue to wear cloth face coverings and social distancing specifically staying six feet away from others in a shared place. Also, installing hand sanitizing stations across the entrance of almost every office buildings and commercial buildings. The people are forced to adapt to these changes due to this pandemic for their own safety and the safety of others. One of the notable changes adapted today are to always keep clean and washing hands frequently with hand sanitizers or soap which is very effective in helping to prevent COVID-19. This is an invaluable life lesson for the people to prioritize personal hygiene in all circumstances even after this pandemic subsides. These adaptations and changes are considered as our “new normal”. Cleaning of visibility dirty surfaces followed by

disinfection is a best practice measure for prevention of COVID-19 and other viral respiratory illnesses in households and community settings [6]. In the event of post COVID-19, cleaning workers are still on the front lines of fighting this global pandemic. It is because they are responsible for deep cleaning, disinfecting and scrubbing the surfaces that are hosts of potentially dangerous germs and viruses. Thus, this stresses that it is very important to obtain knowledge about the process and procedure to handling and managing the green cleaning products. The vulnerability of people exposed to cleaning chemicals is a critical consideration. In the interest of the occupants and those with vulnerabilities, it is important for the facility management to consider initiating a productive building with green cleaning programme. A building manager needs to ensure that such products are actually efficiently used and well managed [26]. Thus, it is important to implement green cleaning practices as it reduces the detrimental impact of conventional cleaning on the environment and to the people that are most exposed to the harmful chemicals.

## CONCLUSIONS

This paper has discussed the benefits of green cleaning implementation during and post COVID-19 pandemic. Cleaning is a mainly part of the toolkit that is required to reduce the spread of the COVID-19 pandemic. Green cleaning aims at balancing and addressing multiple needs [34] such as environmental cleanliness for infection prevention and control, environmental impact, human health effects and so on. The efforts of green cleaning programs are beneficial for sensitive populations which is vital during this unprecedented time. By taking on COVID-19 cleaning and disinfecting jobs by the cleaning workers that are exposing themselves to facilities where the virus may be living, they are putting themselves at a heightened risk. Utilizing conventional chemical cleaners and disinfectants for this job involves prolonged exposure to the chemicals which comes with a potential toxicity risk. Moreover, switching to green cleaning not only good for health and the wellbeing of people but also prevents unnecessary chemicals from being released into the environment. These are the reasons why green cleaning process is relevant and should be taken into consideration during this COVID-19 pandemic. It involves the selection and use of cleaning products as well as operational changes and building design. Many researchers have acknowledged on the importance and benefits of green cleaning and its integrations with sustainable goals. However, limited research has been done on the proper procedures in implementing green cleaning programme and there is no standardized and specific standard or regulations for green cleaning in Malaysia. This lack of readily available data clearly indicates a need for research in this area, but may also pose a challenge for research. Thus, an urgent need is to conduct a further research on the green cleaning that incorporate the processes and procedures or components and requirements according to the standard that should be prescribed. By better understanding the value of green cleaning, its operations, components and requirements, the facility manager teams can leverage sustainability to improve overall health and cleaning efforts, reduce costs, extend buildings' longevity, and ultimately, have a positive impact on the bottom line especially in the event of unprecedented times as COVID-19 pandemic.

## ACKNOWLEDGEMENTS

We gratefully acknowledge financial support from the Malaysian Ministry of Higher Education under project no. RACER/1/2019/TK10/UITM//3.

## REFERENCES

- [1] Sharfuddin S. The world after Covid-19. Round Table [Internet]. 2020 May 3 [cited 2020 Jul 2];109(3):247–57. Available from: <https://www.tandfonline.com/doi/full/10.1080/00358533.2020.1760498>
- [2] WHO. Cleaning and disinfection of environmental surfaces in the context of COVID-19 [Internet]. World Health Organization. 2020 [cited 2020 Jul 19]. Available from: <https://www.who.int/publications/i/item/cleaning-and-disinfection-of-environmental-surfaces-in-the-context-of-covid-19>
- [3] BPHC. Cleaning & Disinfecting to Prevent COVID-19 [Internet]. Boston; 2020 Mar [cited 2020 Jul 8]. Available from: <https://www.epa.gov/pesticide->
- [4] RSPh. Too clean or not too clean? R Soc Public Heal [Internet]. 2019; Available from: [www.rsph.org.uk](http://www.rsph.org.uk)
- [5] Fair D. Issues Of The Environment: Chemical Impacts In Fighting The Spread Of COVID-19 [Internet]. WEMU. 2020 [cited 2020 Jul 23]. Available from: <https://www.wemu.org/post/issues-environment-chemical-impacts-fighting-spread-covid-19>
- [6] Linares A. Cleaning services increase as COVID-19 pandemic continues to unfold [Internet]. The World. 2020 [cited 2020 Aug 1]. Available from: [https://theworldlink.com/news/local/cleaning-services-increase-as-covid-19-pandemic-continues-to-unfold/article\\_94107b5e-6e18-11ea-ba76-bff9bc21d67e.html](https://theworldlink.com/news/local/cleaning-services-increase-as-covid-19-pandemic-continues-to-unfold/article_94107b5e-6e18-11ea-ba76-bff9bc21d67e.html)
- [7] CNBC. Coronavirus: Hand sanitizer sales surge, leading to price hikes [Internet]. Division of NBCUniversal. 2020 [cited 2020 Jul 30]. Available from: <https://www.cnbc.com/2020/03/03/coronavirus-hand-sanitizer-sales-surge-leading-to-price-hikes.html>
- [8] MIDA. CCM expects rising demand for other chemical products to cushion caustic soda margin squeeze [Internet]. Malaysian Investment Development Authority. 2020 [cited 2020 Jul 31]. Available from: <https://www.mida.gov.my/home/10612/news/ccm-expects-rising-demand-for-other-chemical-products-to-cushion-caustic-soda-margin-squeeze/>
- [9] MITI. PROSEDUR STANDARD OPERASI (SOP) [Internet]. 2020 [cited 2020 Aug 1]. Available from: [www.miti.gov.my](http://www.miti.gov.my).
- [10] Durham Region Health Department. Cleaning and Disinfection. 2016; Available from: <https://www.durham.ca/en/health-and-wellness/resources/Documents/PublicHealthInspectionsandInvestigations/CleaningDisinfectingFA.pdf>
- [11] CDC. Guidance for Cleaning and Disinfecting. US Centers Dis Control Prev [Internet]. 2020;1–9. Available from: [https://www.cdc.gov/coronavirus/2019-ncov/community/pdf/Reopening\\_America\\_Guidance.pdf](https://www.cdc.gov/coronavirus/2019-ncov/community/pdf/Reopening_America_Guidance.pdf)



- [12] CDC. Coronavirus Disease 2019 (COVID-19) Cleaning and Disinfection for Community Facilities. CDC. 2020;2019:19–22.
- [13] EPA. List N: Disinfectants for Use Against SARS-CoV-2 (COVID-19). Environ Prot Agency [Internet]. 2020 [cited 2020 Jul 19]; Available from: <https://www.epa.gov/pesticide-registration/list-n-disinfectants-use-against-sars-cov-2-covid-19>
- [14] Sordo F. COVID-19: Eco-friendly Cleaning and Disinfecting Products - Ecobnb [Internet]. ecobnb. 2020 [cited 2020 Jul 19]. Available from: <https://ecobnb.com/blog/2020/05/covid-eco-friendly-cleaning-disinfecting-products/>
- [15] UCSF Institute for Health & Aging. Green Cleaning, Sanitizing, and Disinfecting: A Toolkit for Early Care and Education [Internet]. San Francisco; 2013 [cited 2020 Jul 23]. Available from: [https://www.epa.gov/sites/production/files/documents/ece\\_curriculumfinal.pdf](https://www.epa.gov/sites/production/files/documents/ece_curriculumfinal.pdf)
- [16] WHO. Hospital Preparedness for Epidemics [Internet]. World Health Organization. 2014 [cited 2020 May 29]. Available from: <https://www.who.int/publications-detail/hospital-preparedness-for-epidemics>
- [17] Delclos GL, Gimeno D, Arif AA, Burau KD, Carson A, Lusk C, et al. Occupational Risk Factors and Asthma among Health Care Professionals. *Am J Respir Crit Care Med* [Internet]. 2007 Apr 1 [cited 2020 Jul 21];175(7):667–75. Available from: <http://www.atsjournals.org/doi/abs/10.1164/rccm.200609-1331OC>
- [18] Rosenman KD, Reilly MJ, Schill DP, Valiante D, Flattery J, Harrison R, et al. Cleaning products and work-related asthma. *J Occup Environ Med*. 2003;45(5):556–63.
- [19] EPA. National Programs to Assess IEQ Effects of Building Materials and Products. 2010;1–50. Available from: [https://www.epa.gov/sites/production/files/2014-08/documents/hal\\_levin\\_paper.pdf](https://www.epa.gov/sites/production/files/2014-08/documents/hal_levin_paper.pdf)
- [20] Tansley E. The Environmental Impact of Disinfectant Usage [Internet]. TWinFM. 2020 [cited 2020 Jul 21]. Available from: <https://www.twinfm.com/article/the-environmental-impact-of-disinfectant-usage>
- [21] Quan X, Joseph A, Jelen M. Green Cleaning in Healthcare: Current Practices and Questions for Future Research. Health Care Collaborative Paper Series. University of Illinois, Chicago School of P Public Health. 2011;(September).
- [22] Markkanen P, Quinn M, Galligan C, Bello A. Cleaning in healthcare facilities: Reducing human health effects and environmental impacts. *Heal Care Res Collab Pap Ser* [Internet]. 2009;(November 2014). Available from: [http://noharm.org/lib/downloads/cleaners/Cleaning\\_in\\_Healthcare\\_Facilities.pdf](http://noharm.org/lib/downloads/cleaners/Cleaning_in_Healthcare_Facilities.pdf)
- [23] Practice Greenhealth. Green cleaning [Internet]. [cited 2020 Jul 21]. Available from: <https://practicegreenhealth.org/topics/safer-chemicals/green-cleaning>
- [24] Ramli NA, Zawawi EM, Ariff NRM, Kadir SS, Zainol NN. Green Cleaning: A Study on Benefits for Malaysian School Building. 2019;8.
- [25] BETCO. Sustainable Green Cleaning: Cleaning for Health and the Environment [Internet]. 6th ed. Toledo, Ohio: Betco Corporation; 2008 [cited 2020 May 19]. 60 p. Available from: <https://docplayer.net/19737142-Sustainable-green-cleaning.html>
- [26] Zainol NN. A STRUCTURAL MODEL OF GREEN CLEANING COMPONENTS AND REQUIREMENTS FOR GREEN BUILDINGS. 2016;
- [27] Young J, Schwinghammer K, Steen E, Zaffrann D. Clean Sweep: How a New Approach

- to Cleaning Commercial Buildings in the Twin Cities Can Protect Our Health and the Environment While Securing Jobs and Saving Money [Internet]. Blue Green Alliance. 2010 [cited 2020 Jul 22]. p. 1–15. Available from: <https://www.bluegreenalliance.org/wp-content/uploads/2016/07/CleanSweep.pdf>
- [28] UCONN. Green Cleaning: Exposure Characterization and Adoption Process Among Custodians [Internet]. 2013 Jun [cited 2020 Jul 24]. Available from: [https://health.uconn.edu/occupationalenvironmental/wpcontent/uploads/sites/25/2016/01/Green Cleaning Workbook\\_v21\\_sm.pdf](https://health.uconn.edu/occupationalenvironmental/wpcontent/uploads/sites/25/2016/01/Green-Cleaning-Workbook_v21_sm.pdf)
- [29] Young J, Schwinghammer K, Steen E, Zaffrann D. CLEAN SWEEP. How a New Approach to - PDF Free Download [Internet]. Blue Green Alliance. 2010 [cited 2020 Jun 8]. p. 3–5. Available from: <http://docplayer.net/31106215-Clean-sweep-how-a-new-approach-to.html>
- [30] Zainol NN, Mohammad IS, Baba M, Woon NB, Nazri AQ. Green cleaning: An essential aspect of Malaysian green buildings. *J Teknol.* 2015;75(10):65–70.
- [31] BETCO. Sustainable Green Cleaning: Cleaning for Health and the Environment. *Train Libr Workb.* 2015;60.
- [32] NIH. New coronavirus stable for hours on surfaces [Internet]. National Institutes of Health . 2020 [cited 2020 Aug 30]. Available from: <https://www.nih.gov/news-events/news-releases/new-coronavirus-stable-hours-surfaces>
- [33] CDC. How to Protect Yourself & Others [Internet]. Centers for Disease Control and Prevention. 2020 [cited 2020 Aug 30]. Available from: [https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html?CDC\\_AA\\_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fprepare%2Fprevention.html](https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html?CDC_AA_refVal=https%3A%2F%2Fwww.cdc.gov%2Fcoronavirus%2F2019-ncov%2Fprepare%2Fprevention.html)
- [34] Ashkin S. Sustainable Green Cleaning [Internet]. *Cleaning & Maintenance Management.* 2015 [cited 2020 Jul 23]. Available from: <https://www.cmmonline.com/articles/sustainable-green-cleaning>

## **EXPERIMENTAL ESTIMATION OF WATER VELOCITY IN A SELECTED UNREGULATED RIVER (RIVER DINDIMA) FOR MICRO-HYDROKINETIC POTENTIAL**

Michael C. Ohakwere-Eze <sup>1,\*</sup>, Righteous Ombu<sup>2</sup>, James Audu<sup>1</sup>, James Emmanuel<sup>1</sup> and Henry I. Ikeri<sup>3</sup>.

<sup>1,\*</sup>Department of Physics, Federal University of Kashere, Gombe State, Nigeria.

<sup>2</sup>Department of Physics, Federal Polytechnic Ekowe, Bayelsa State, Nigeria.

<sup>3</sup> Department of Industrial Physics, Enugu State University of Science and Technology, Enugu State, Nigeria.

\*Corresponding author email; michael.ohakwereze@gmail.com  
Phone number; +234 7035746293

### **ABSTRACT**

Micro-hydrokinetic river (MHR) system is one of the promising technologies to be used for remote rural electrification. It simply requires the flow of water instead of elevation or head, leading to expensive civil works. It also demonstrates an economic benefit offered by a MHR system when compared to the commonly used systems such as solar, wind and diesel generator (DG) at the selected study site. A novel technique of estimating the daily average water velocity data in unregulated rivers is proposed. The modelling of regression equation for water velocity estimation was performed and two regression model equations were generated to estimate both water level and water velocity on-site and proven to be valid as the coefficient of determination values ( $R^2$ ) had been 81.7% and 81.4% respectively. The daily average water level from river Dindima River was measured concurrently for two months (94 samples) as training data. Both datasets were analysed using the regression analysis method. Eight regression models were selected and analysed. The quadratic model equation was however chosen due to its significant of correlation ( $P$ ) less than 0.01 as well as collinearity. The river showed that the rising water level at downstream is linearly proportional to the rise in water levels at the upstream of the river. Nevertheless, the relationship between water level and water velocity at the project site is proven to be non-linear when a quadratic curve was applied. The combination of both regression model equations can be used to estimate long-term time series water velocity data for unregulated river in remote areas.

**Keywords:** Hydrokinetic; Energy assessment; Unregulated river; water velocity; Regression Analysis; modelling; River Dindima.

### **INTRODUCTION**

A solution to remote rural electrification is made possible by means of approaches/techniques such as grid-extension, diesel generator (DG) or a small-scale off-grid renewable energy system. However, grid-extension for small isolated remote areas can be expensive. Harnessing

hydrokinetic energy is similar to converting wind energy into electrical energy. It generates electricity by making use of underwater wind turbines to extract the kinetic energy of flowing water instead of the potential energy of falling water. Hence, no construction of dams or diversions is necessary; it therefore creates a minimal environmental footprint [Mosallat, 2012; Van *et al.*, 2011].

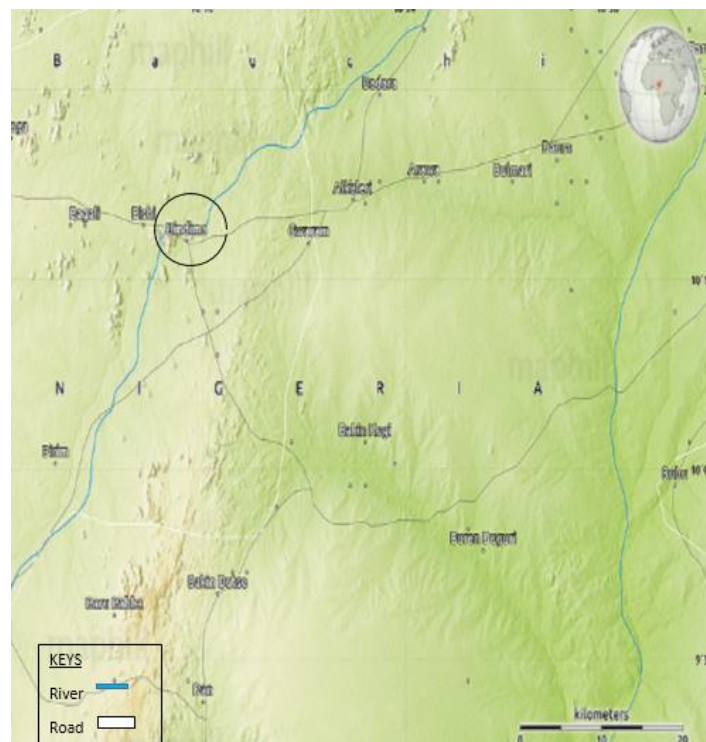
To improve the living condition of rural residents, there is a need to discover a reliable and low cost electrification method. Considering all renewable source, micro-hydrokinetic system emerged as the most official and cost-effective approach as a solution for remote areas electrification, especially in small villages located at hilly terrains.

The aim of the research is to estimate the water velocity of an unregulated River for micro-hydrokinetic potentials for rural residents not served by the grid and are close to proximity to flowing water.

The objectives of this study are firstly, to estimate the water level data at Dindima River by employing the regression analysis method. Secondly, to validate the regression equation model by using the highest value of coefficient of determination ( $R^2$ ) and the significant coefficient of correlation ( $p$ ) less than 0.01. Thirdly, to estimate the water velocity data at Dindima River by employing the regression analysis method.

### Study Area

Dindima is a village found in Duguri district of Alkaleri local government area, Bauchi state. The study area is enclosed in a circle in figure 1. Its geographical coordinates are  $10^{\circ} 30' 13''$  North,  $10^{\circ} 17' 27''$  East. Rainfall start around April/May with its peak in August and end by October while flood occurs during the raining season (July to September). The settlement is found very close to the river, also it is primarily used for irrigation, fishing, etc. The basic occupation in Dindima is farming.



**Figure 1.** Map of the study area (© Alkaleri Local Government Council).

## Theory

The regression analysis method has been used to determine the relationship of water levels the study site and a reference site (Dadin-Kowa dam) by using the mathematical model equation shown in equation 1. The regression analysis incorporates five types of regression, such as Linear, Logarithmic, Quadratic, Cubic and Exponential curve type.

The regression model equation for this study had been selected based on two criteria outlined by Bhat *et al*, 2014, which are the highest value of coefficient of determination ( $R^2$ ) and the significant coefficient of correlation ( $p$ ) less than 0.01, in regression simulation results represented as (Sig. < 0.01).

The regression model is considered as the best fit model if the value of the coefficient of determination ( $R^2$ ) value exceeds 70% (Liu, *et al*, 2003). It is expressed as equation 1.

$$R^2 = 1 - \frac{\sum_{i=1}^N (y_i - \hat{y}_i)^2}{\sum_{i=1}^N (y_i - \bar{y})^2} \quad (1)$$

Where N is the number of observations in the model,  $y$  is the dependent variable,  $\bar{y}$  is the mean of the  $y$  values and  $\hat{y}$  is the value predicted by the model.

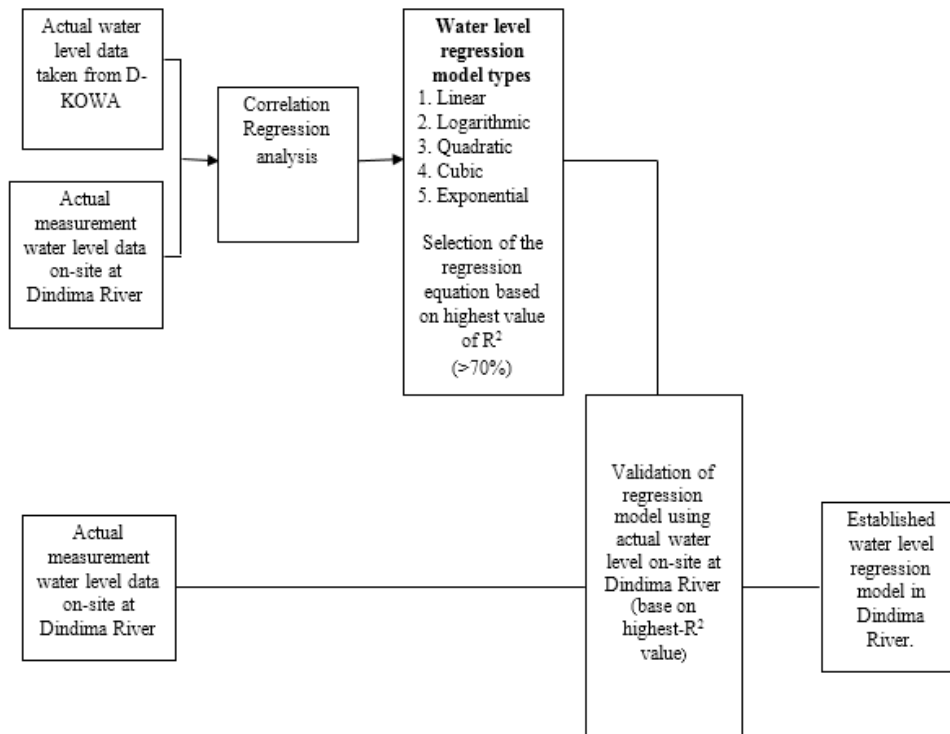
## MATERIALS AND METHODS

The following materials were used:

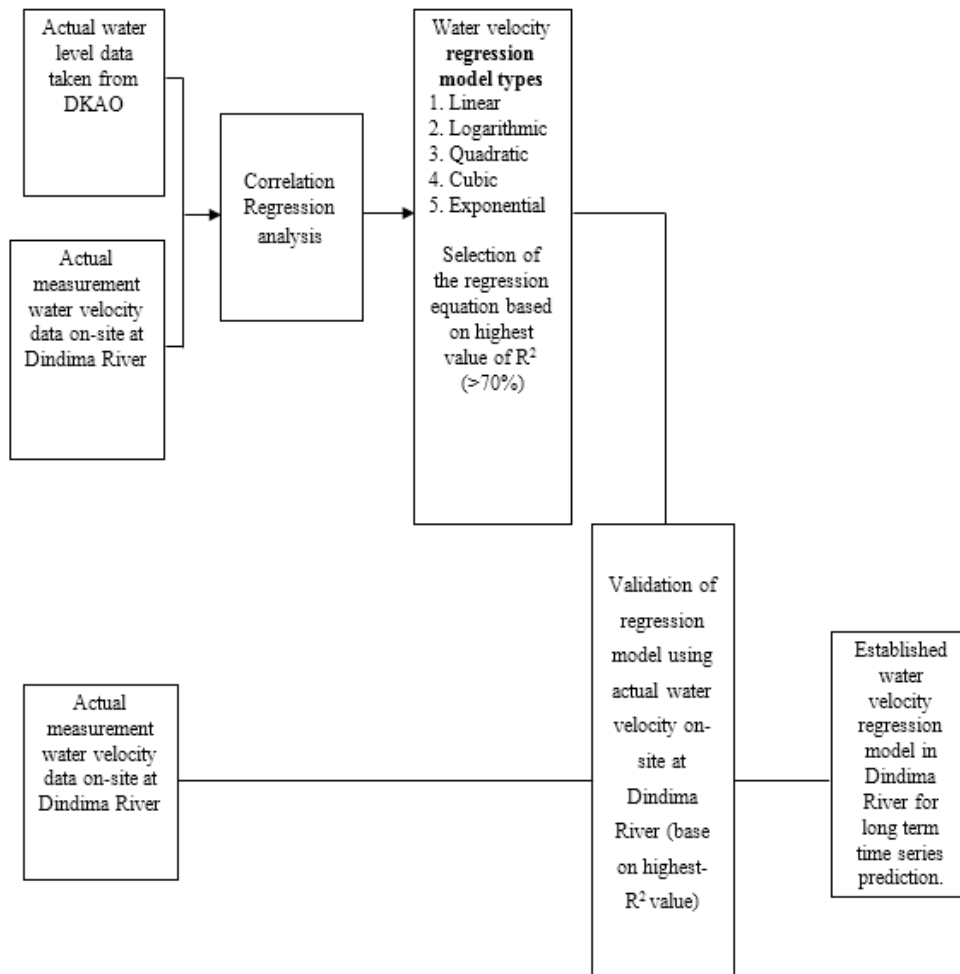
- Driftwood (250g) - This is used for estimating the velocity of the river.
- Digital weighing balance - This is used for measuring the mass used on-site.
- Field notebook - It is used for recording data on-site.
- Tape - It is used for taking measurement from point A to point B.
- Stop watch - It is used for taking time (duration) in seconds.
- Meter stick - It is used for measuring the depth of the river.

The methods adopted were modified after Saupi *et al.*, (2018) as illustrated in figures 2 and 3. Stage one compare the daily average water level data on-site and the actual water level data accumulated from Upper Benue River Basin from Dadin –kowa Area Office to establish any correlation. Stage two estimates daily average water velocity data on-site throughout the year by using the actual water level data from the site itself.

The regression analysis method was used to identify the relationship between water velocity and water level on-site, thus providing the regression model equation by adhering to the flowchart illustrated in figure 3. Finally if validated, the long-term time series of the daily average water velocity data on-site can be estimated throughout the year by using the daily average water level data.



**Figure 2.** Flowcharts to estimate water level at Dindima River (on-site).



**Figure 3.** Flowcharts to estimate water velocity at Dindima River (on-site).

The daily average water level data were measured on-site by measuring the depth on daily basis for two months (47 days). The water level data had been taken twice a day at 7:00 a.m. and 5:00 p.m. daily average water level data was obtained.

The accuracy of water velocity measurement in unregulated river demands special equipment that can only be operated by experts such as Acoustic Doppler Current Profile (ADCP). However, due to the absence of such instrument the Surface Floating Method (SFM), was used to measure water velocity data on-site as it is the most economical way for collecting data, which can be handled by workers without specific skill and the data could also be collected throughout the year, even during flood season (Kunaifi, 2009). A driftwood of 250g was placed at a point A and allowed to drift with the flow direction to point B which is 2 meters apart from point A (Figure 4). From the time interval, the velocity was then be computed.



**Figure 4.** Measurement of water velocity data using Surface Floating Method.

## RESULTS AND DISCUSSION

### Correlation Analysis

Based on the result (Table 1), water level data on-site showed poor relationship with the reference site for the period of study hence regression analysis process was dropped for those set of variables. Conversely, there exist a strong correlation of 81% and significant P-value of 0 which suggests strong relationship between the water level and water velocity on-site. Therefore, it can be interpreted that the increment in water level can significantly hike the water velocity on-site.

Since the parameters showed strong relationship between each other, they were retained for the next process that involved regression analysis modelling.

**Table 1.** Correlation results among variables

Water level at Dindima river		
Water level at Dadin-Kowa dam	Pearson Correlation	0.33
	(Sig.) P < 0.01	0.001
	N	39
Water velocity at Dindima river	Correlation Coefficient	0.81
	(Sig.) P < 0.01	0.000
	N	47

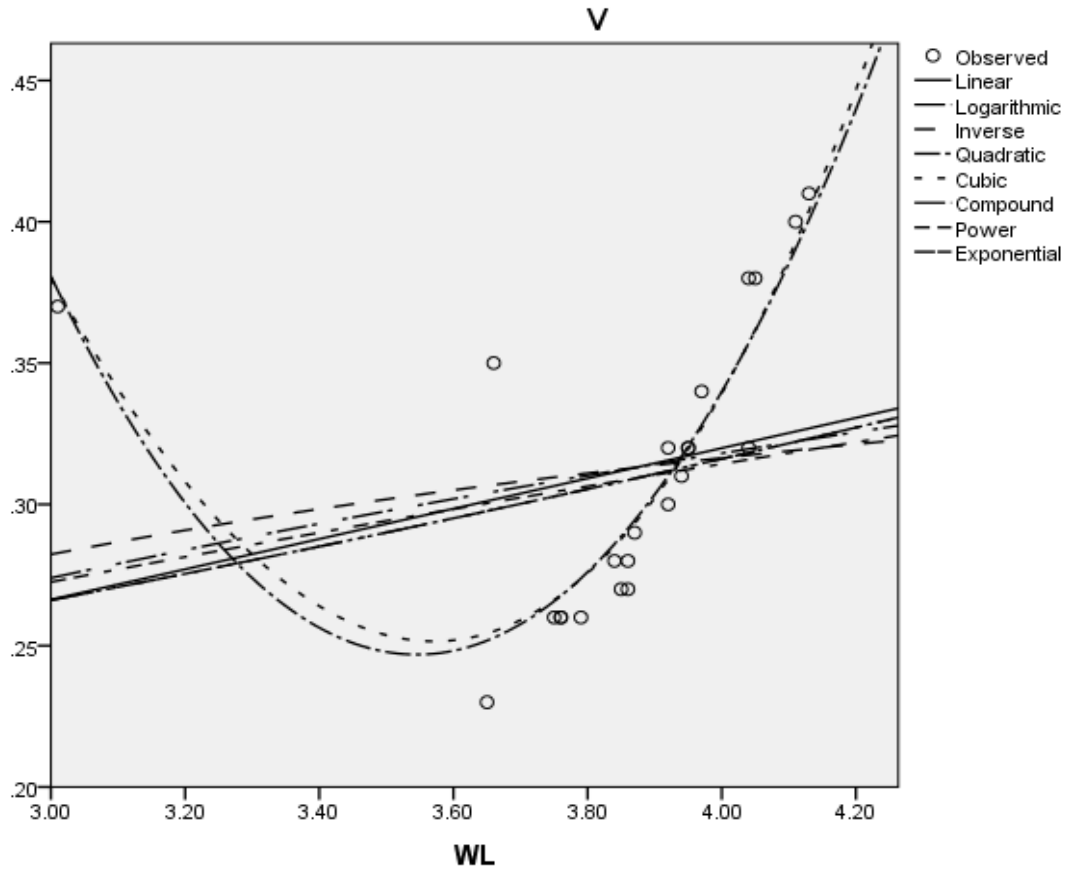
### Estimation of Water Velocity using Regression Analysis Method

The regression analysis was performed and involved eight types of regression models, as illustrated in figure 5 and table 2. The dependent variable is the velocity (v) while the independent variable is the water level (WL). The regression model of linear (57%), logarithmic (37%), inverse (21%), compound (59%), power (38%) and exponential (59%) showed the lowest R square values. That of quadratic (75%) and cubic (76%) exhibited the highest R square values however the quadratic model equation was chosen due to its significant coefficient of correlation (p) less than 0.01 as well as its colinerity.

**Table 2.** Model summary and parameter estimates.

Equation	Model Summary					Parameter Estimates			
	R Square	F	df1	df2	Sig.	Constant	b1	b2	b3
Linear	.057	1.277	1	21	.271	.106	.054		
Logarithmic	.037	.803	1	21	.380	.105	.153		
Inverse	.021	.450	1	21	.509	.419	-.409		
Quadratic	.749	29.845	2	20	.000	5.904	-3.191	.450	
Cubic	.758	31.380	2	20	.007	2.128	.000	-.441	.082
Compound	.059	1.322	1	21	.263	.159	1.188		
Power	.038	.840	1	21	.370	.158	.496		
Exponential	.059	1.322	1	21	.263	.159	.172		





**Figure 5.** Analysis result of eight types water velocity regression models.

The developed quadratic model equation is therefore according to equation 2.

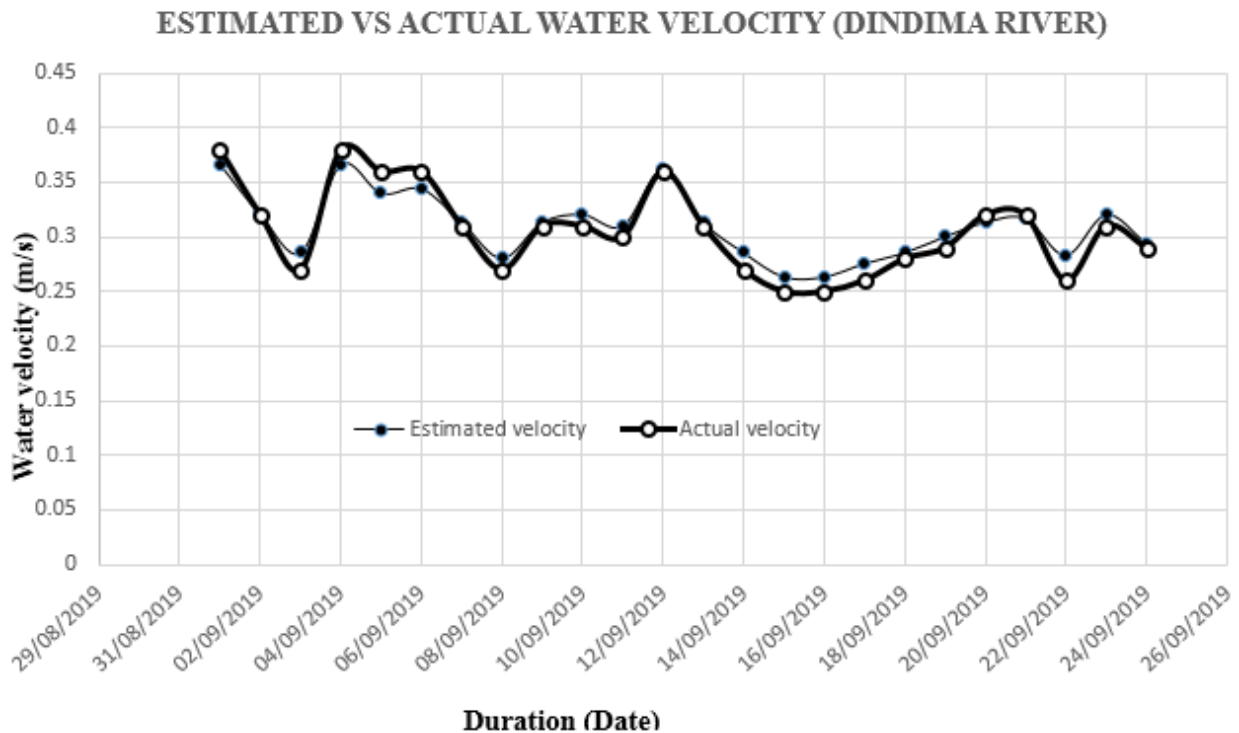
$$v = 5.9 - 3.19WL + 0.45(WL)^2 \quad (2)$$

Where  $v$  is the water velocity in meter per second (m/s) and  $WL$  is the water level in meter (m).

### Validation of Water Velocity Regression Model

By applying the model we obtained in equation 2, the estimated water velocity data on-site recorded from September, 2019 had been generated. At the time of measurement of actual water velocity data on-site, the validation of the regression model had been carried out concurrently, as illustrated in figure 3.

The plots according to figure 6 showed a very good fit between the estimated and actual velocities moreover correlation analysis carried out gave a correlation coefficient of 0.99 thus validating our results and confirming the model.



**Figure 6.** Variance between estimated and actual water velocities on-site.

## CONCLUSION

1. The Dindima River showed that its rising water level has no relationship with the Dadin-kowa River. Nevertheless, the relationship between water level and water velocity at the study site is proven to be non-linear when a quadratic curve was applied.
2. The standard of procedure proposed is proven to be adequate and reliable for predicting the daily average water velocity data throughout the year for unregulated rivers especially in the remote area of Akko Local government and environs.
3. The ability to estimate such water velocity data offers opportunities and encouragement to other researchers to continue studies pertaining to hydrokinetic power generation systems, particularly for remote area electrification in Dindinma village and surrounding villages.
4. This procedure is also highly recommended to be extended to other remote area rivers around the country especially for sites with limited water discharge and rainfall data. Furthermore, this method is much cheaper, safer and does not require the specific skills for data measurement on-site.

## REFERENCES

- [1] Anyi M., Kirke B., and Ali S. (2010). Remote Community Electrification in Sarawak, Malaysia. *Renewable and Sustainable Energy Reviews*, 35(7): 1609-1613.
- [2] Bhat, S.A.; Meraj, G.; Yaseen, S. and Pandit, A.K. (2014.). Statistical Assessment of Water Quality Parameters for Pollution blackfoot disease area in Taiwan. *Sci. Total Environ.* 313: 77–89.

- [3] Boccaletti C., Fabbri G., Marco J. and Santini E. (2008). An Overview on Renewable Energy Technologies for Developing Countries: the case of Guinea Bissau, *International Conference on Renewable Energy and Power Quality (ICREPQ'08)*, 12-14 March 2008, Santander, Espana.
- [4] Klunne, W.J. (2013). Small Hydropower in Southern Africa - an Overview of Five Countries in the Region. *Journal of Energy in Southern Africa*, 24(3): 14-25.
- [5] Kunaifi, K. (2009). Options for the Electrification of Rural Villages in the Province of Riau, Indonesia; Murdoch University: Perth, Australia.
- [6] Liu, C.W.; Lin, K.H. and Kuo, Y.M. (2003). Application of factor analysis in the assessment of groundwater quality in a blackfoot disease area in Taiwan. *Sci. Total Environ*, 313: 77–89.
- [7] Mosallat F. (2012). Specialized Power-Electronic Apparatus for Harnessing Electrical Power from Kinetic Hydropower Plants. Master's Thesis, Department of Electrical and Computer Engineering, University of Manitoba, July 2012.
- [8] Saupi, A.F.M., Mailah, N.F., Radzi, M.A.M., Mohamad, K.B., Ahmad, S.Z., Soh, A.C. (2018). An illustrated guide to estimation of water velocity in unregulated river for hydrokinetic performance analysis studies in East Malaysia. *Water*, 10, 1330: 1-14.
- [9] Van Arkel R., Owen J., Allison S., Tryfonas T., Winter A., Entwistle R., Keane E. and Parr J. (2011). Design and Preliminary Testing of a Novel Concept Low Depth Hydropower Device, *Oceans'* 11: 19-22.

## **THE IMPACT OF GREEN SPACES ON RESIDENTIAL PROPERTY VALUES IN MALAYSIA**

**M.A Sulaiman<sup>1</sup>, N.H Hashim<sup>1</sup>, N.N Zainol<sup>1</sup>, M.N Alias<sup>1</sup>, W.Z Wan Yusoff<sup>2</sup>**

<sup>1</sup>Faculty of Architecture, Planning and Surveying, Universiti Teknologi MARA, 40450 Shah Alam, Selangor, Malaysia.

<sup>2</sup>Faculty of Technology Management & Business Universiti Tun Hussien Onn Malaysia  
86400 Parit Raja Johor, MALAYSIA

\*Email:

azwan@uitm.edu.my

Phone: +60134234344

### **ABSTRACT**

This paper presents the impact of green spaces on property values in Malaysia. Green spaces are any place prepared with grass, flowers, trees, benches, gardens, parks and playgrounds, or meadows or other decorative or urban furniture elements used as decoration or for public uses. It is now assumed that sustainability indicators for urban planning will provide more criteria for urban green spaces, as well as indexes representing the community's satisfaction and perception of their living environments. In addition to the many economic, ecological and psychological benefits, urban green spaces will play a very important role in the creation of sustainable communities. Areas that are distinguished by a rise in the green coverage rate may help people transition to a healthier lifestyle. Many people prefer to choose eco-friendly houses due to the health and well-being of the occupants. The most important is in the reduction of operating energy and water costs from day one and for the entire life cycle of the building. Buying a house is a major decision that homebuyers will make because expenditure on homeownership has an influence on the homeowner's quality of life. This paper discusses the benefits of urban green spaces based on sustainability aspects, the physical, social and economic dimensions and the impacts of green spaces towards property values. The paper aims to attempt sustainable green spaces evaluation criteria to examine the interaction between urban green spaces and their community to get most of their benefits. This study employs an approach to distributing a questionnaire to the respondents and optimize the use of descriptive analysis. The results revealed that although green spaces have many positive impacts in terms of environmental, ecological and psychological and also as an important role in sustainable community development, it shows that location and accessibility are the most factors that give more impact on property values.

**Keywords:** Urban green spaces; community development; sustainability; property values.

## INTRODUCTION

The importance of green spaces and its value have captured the attention of many levels of people including government, local authorities, developers, planners, buyers of property, residents, and so on. Park can create more attractive places for our cities and neighborhoods to live and work. Green spaces offer various opportunities to benefit individual, social, economical and environmental. Green spaces, for instance, offer individual opportunities to enrich the quality of life of all ages and abilities. that park and landscape are now one of the most important points of sale and have become a tool for developers to attract prospective buyers. Therefore, by introducing elements such as natural, green spaces and park allocation to their design, current developers who have noticed such demands tend to improve the value of their property [1]. Although many agree that park is important, some developers tend to give the development of park a basic guideline approval. There is a severe lack of park space in many of their housing developments.

This paper has two goals in line with the above-mentioned issues. The objectives are to determine park related and non-park related factors that affect the value of houses and to identify the importance of parks to the house residents. There are many and varied park values for communities. One of the advantages is to improve the environment. Park areas with many trees generally contribute to the preservation and purification of the environment. By creating shades, trees in parks, or green spaces can help lower the temperature. Park also contributes to air pollution reduction and pollutant reduction [2]. Park can also serve a social function by providing a meeting place to develop social ties and setting for people or residents. Through outdoor education, the existence of parks in urban areas introduces people to nature. Another advantage is economic [3] besides the crime is lower when the park exists [4]. Thus, settings in which there are more trees and vegetation in housing residents can inhibit crime, aggression and violence. The availability of recreational opportunities, consideration of alternatives in the types and locations of the park is an important factor in the quality of life for businesses who choose where to live and for individuals who choose a place to live [5]. For housing, if it is adjacent to the parking area, the value of the house may increase. Previous research has shown that parks can also improve the sense of well-being. The park users finding themselves considerably healthier than non-park users [6]. People with regular physical activity benefit from reduced risk of heart disease, hypertension, and weight loss. The significant impact of urban green spaces on real estate prices is confirmed by numerous studies carried out over the last few decades. A valuable overview of the literature concerning this issue was provided by Crompton [7]. Among 30 studies was analysed, there were only five not supporting the proximity principle for example that having a park nearby raises property prices [7]. One of the first studies related to this problem was conducted in the USA in 1960. Due to the applied methodology, however, the results were not consistent. The research carried out showed that the benefits of an attractive location, such as on the shoreline, may contribute to the growth in the value of the property [8]. In another study, no and uniform influence of the neighborhood of recreational areas on real estate prices was observed. By the analysis of literature, the studies conducted so far may be arranged by considering first the applied research method, and then the type and size of green spaces and the kind of property.

Research has shown that the degree of influence depends on the type of green spaces that property borders and on the distance from these areas [9]. It has also been pointed out that the degree to which a park influences its neighbourhood is dependent on its attractiveness, extra facilities and landscape [10]. Studies also differ regarding the type of properties for which the influence of green

spaces on prices was examined. Some studies deal with the impact of green areas on the prices of flats [11]. Although many of the benefits associated with public green spaces appear to be obvious and easy to describe, they are often much more difficult to quantify. Green spaces in urban and suburban areas have traditionally been equipped with public amenities that do not have a fixed market price, but it has become increasingly common to measure them in terms of their monetary contributions to their surrounding communities. According to Nicholls 2005, there is also a need to turn the many assumptions about the intrinsic benefits of green spaces into concrete quantitative assessments of their importance. Recent trends towards increased land development, particularly in urban areas, make it important to be able to determine the economic values of public parks and green spaces in order to ensure their existence and designation. Early literature supports the idea that green space triggers a rise in property prices because homeowners and tenants are willing to pay more for the perceived advantages of living close to green space (Crompton 2001). Since green space provides many different benefits, such as environmental, leisure, transport, aesthetic and health-related, there is no single method for calculating all such benefits at the same time (Nicholls 2005). However, the influence of green spaces on residential property values is very difficult to measure due to the complex relationship between house prices and environmental factors (Hui et al. 2007). Environmental factors are what people would consider before buying a car. House and such factors are expressed in property prices, such as noise, air quality and the accessibility of green spaces (Freeman 1979; Tyrvaenen 1997). They concluded that residential properties with good tree cover could increase the overall selling price by as much as 6 percent to 9 percent. Anderson and Cordell (1988) surveyed 844 single-family residential properties in Athens, Georgia, USA, and found that tree-lined landscaping was correlated with a 3.5 to 4.5 per cent rise in sales prices. In addition, Luttik (2000) studied almost 3000 house transactions in eight towns or regions in the Netherlands and found that a nice view could lead to a significant increase in house prices, especially if the house overlooks water (8 percent to 10%) or open space (6 percent to 12%). Based on these previous research, Crompton (2001, 2005) suggested that a positive 20 per cent effect on the abutting or fronting properties of a passive park was a fair guideline. Since urban green space has a positive impact on property values, but how far does this effect reach? Based on the sales data for terraced houses in Salo, Finland, Tyrvaenen and Miettinen (2000), distances of up to 600 meter had a major positive impact on housing prices. If the distance was more than 600 meter, the impact on the price was not statistically significant at 5%. Bolitzer and Netusil (2000) have discussed this problem using data from Portland, Oregon. Other than that, strong social connections within the urban community may promote an atmosphere that is linked to connection, sense and intention, while lack of integration can lead to feelings of hopelessness, raising the risk of depressive symptoms (Abada et al., 2007). A sense of community between urban residents provides an opportunity to get to know their communities and friends in the city.

## **METHODS AND MATERIALS**

Research methodology discussed the structure of the research. It helps to well understand the basic stages of methodology that have been carried out thus can achieve the objectives of the study. To achieve the objectives of the research, several techniques were employed including a review of the research area, literature review and a survey of residents living in proximity to the park that used qualitative methods.

**Research Area:** The research area comprises the residential area in Kuala Lumpur, Malaysia. The map of peninsular Malaysia is shown in figure 1. Kuala Lumpur residential area is chosen because it is a strategic area. The residential area also contains a variety of green spaces such as neighborhood parks, pocket parks, playgrounds and many more.



Figure 1. Map of Peninsular Malaysia

**Literature Review:** In this regard, the literature review is considered as part of the document analysis. It plays an important role as it provides background information that provides a link with the analysis stage. The authors have done some research on the definition, types and benefits of green spaces towards the community. A wide range of documents such as planning guidelines, government reports, plans, and journals related to green spaces and property values were referred to, such as the planning guidelines for recreational and open space [12]. Other essential sources include the Property Market published by the Valuation and Property Services Department (JPPH) under the Malaysian Ministry of Finance. In relation to the subject's concern with the research, numerous studies elsewhere use various techniques to investigate the impacts of green spaces on property values. Among others, they used Hedonic Analysis and contingent valuation is widely investigated by many researchers.

**Qualitative Survey:** This survey was used to ascertain residents' perceptions of the values of the park to the house residents. Survey techniques are widely and often used in descriptive and explanatory research [13]. The survey was administrated within one month using questionnaires. The total number of respondents involves in this survey are 106. The questionnaire is designed and presented in written form. Each respondent was asked to read the questions themselves and mark answers on a questionnaire. This analysis was conducted using descriptive analysis and cross-tabulation in order to achieve the research objective. All given answers are analyzed and formatted into percentages and tables format. The convenience non- random sampling was applied as this method refers to the situation whereby not everyone has an equal opportunity to be selected as samples (Shamhuri, 2004). In this regard, the basic criterion was the respondents are the house

owners. As such, the non-house owners were disqualified to participate in the survey. In obtaining the main primary data, the main source of information was the house owners because they have a major role in addressing the current issues pertaining to the impacts of recreation areas on property values. The questionnaire was divided into three (3) sections. Section one (1) consists of the demographic background of the respondents while section two (2) covers the factors that affect house values while the last sections include the importance and values of the park to the house residents. The questionnaire contains structure, close-ended and Likert scale questions. The analysis using the Statistical Package for Social Science Research (SPSS) software will evaluate which value and the impacts of green spaces on residential property values.

## RESULTS AND DISCUSSION

The results of this study show that in terms of the gender of respondents, 69.8% of them are female represent 74 respondents and 30.2% are male with 32 over 106 respondents with most of the respondents' age is between 18-30 years old. The highest races of respondents were Malaysian represent 93.4% of respondents while the least races who responded to this survey come from the Chinese group where 0.9%. The other 5.7% represent 6 respondents are from Indian and Sabah and Sarawak. Most of the respondents with bachelor's degree holders as the highest percentage for educational background. It shows that 56.6% represents 60 respondents are still a student and followed by 21.7% percent (23 respondents) are work in the private sector. The lowest number or percentage of respondents with 0.9% (1 respondent) for others represents a retired respondent. In terms of monthly salary, the majority (57.5% represent 61 respondents) received are no income. Table 1 shows a summary of the result of the socioeconomic of respondents.

**Table 1.** Result for Socioeconomic of Respondents

ANALYSIS OF TOTAL PERCENTAGE FOR SOCIOECONOMIC OF RESPONDENT					
Gender	(%)	Ages	(%)	Races	(%)
Male	30.2	18-30 years old	93.4	Malay	93.4
Female	69.8	31-39 years old	3.8	Chinese	0.9
		40-49 years old	0.9	Others	5.7
		> 50 years old	1.9		
Educational Background	(%)	Occupation	(%)	Income	(%)
SPM	5.7	Student	56.6	No Income	57.5
Diploma	17.0	Public Sector	7.5	Below RM2,001 - RM3,001	24.5
Bachelor 's Degree	73.6	Private Sector	21.7	RM3,001-RM4,001	11.3
Master	0.9	Self-Unemployed	5.7	RM4,001-RM5,001	5.7
PHD	0.9	Unemployed	7.5	Above RM5,001	0.9
Others	1.9	Others	0.9		



Table 2 below shows the result of the frequency of visiting green spaces, purpose of visiting and their opinion on benefit of green spaces.

**Table 2.** Result for Opinion of Respondents

<b>RESULT OF TOTAL PERCENTAGE FOR RESPONDENTS'S OPINION</b>					
<b>Frequency of Visiting</b>	<b>(%)</b>	<b>Purpose of Visiting Recreation</b>	<b>(%)</b>	<b>What do you think about the recreation areas?</b>	<b>(%)</b>
1-3 times a week	24.5	For leisure and recreation	6.7	Can reduce health inequalities, improve well-being and aid in treatment of mental illness	82.1
3-5 times a week	4.7	Reduced stress	22.6	Improve self-esteem	4.7
Twice a month	58.5	For family bonding	9.4	Build family unity	8.5
Others	12.3	Others	0.9	Promote sensitivity to cultural diversity	1.9
				Others	2.8

From the table above, it shows that most of the respondents visit the recreation areas only twice a month with the total percentage is 58.5% (62 respondents) and the least total percentage is 12.3% represent 13 respondents said that they visit the recreation areas rarely. Recreation is an essential part of human life and finds many different forms that are naturally shaped by individual interests, but also by the social construction that surrounds it. Recreational activities can be active or passive, outdoors or indoors, healthy or harmful, and useful for society or detrimental. A large portion of leisure activities is known as interests, which are activities undertaken daily for fun. The most purpose of respondents visiting the recreation areas is for leisure and recreation such as reading, playing or sports, resting, relaxing and enjoying life with the total percentage is 67% represent 71 respondents voted for this purpose. Besides, 22.6% (24 respondents) said that more time spent in recreation areas will help them fight against mental health problems such as depression, anxiety, and stress.

Ensuring that more residents have access to parks or recreation areas and outdoor activities is a vital way to improve such good health and quality of life consequences on the city. Besides, the least of the total percentage of 9.4% represents 10 respondents who said that they go to the recreation areas for family bonding. In conclusion, we can see that most of the respondents visit the recreation areas for leisure and recreation. Visiting recreation areas or do some outdoor activities at the recreation areas lends itself to both physical and mental health benefits. In fact, the two are so linked that improving one directly improves the other. A previous study shows that there is a link between the built environment and the physical, social, and economic health of a community. Recreation areas can promote active lifestyles, build healthy communities, and lower health care. the results show that most of the respondents give their opinion towards recreation areas with the highest percentage is 82.1% represent 87 respondents said that it can reduce health inequalities, improve well-being and aid in the treatment of mental illness. That is

because, as we know, there are tons of plants that can give us some fresh air. Besides, 8.5% represent 9 respondents give their opinion that the benefit of recreation areas can build family unity and follow by 4.7% (5 respondents said it can improve self-esteem. The least result shows that 1.9% represent 2 respondents said it can promote sensitivity to cultural diversity. In a nutshell, green spaces have significant importance in the life of the settlements. The areas with high green-coverage rates have ecological and environmental importance. These green spaces can improve the urban climate, abate the urban heat-island effect by their ecological-balancer function and reduce environmental damages. Through their social importance, open spaces can help the residents in adjusting to a healthy lifestyle. By their aesthetic importance, they determine the character of the settlements, ameliorating the built-up character of the cities.

**Table 3.** Result for Factors Affecting Before Purchasing A House

<b>Location and Accessibility</b>				
<b>Valid</b>	<b>Ranking</b>	<b>Frequency</b>	<b>Percent (%)</b>	<b>Cumulative Percent</b>
	2	2	1.9	1.9
	1	104	98.1	98.1
	Total	106	100	100
<b>Facilities</b>				
<b>Valid</b>	<b>Ranking</b>	<b>Frequency</b>	<b>Percent (%)</b>	<b>Cumulative Percent</b>
	3	16	15.1	15.1
	2	90	84.9	84.9
	Total	106	100	100
<b>Physical Environment</b>				
<b>Valid</b>	<b>Ranking</b>	<b>Frequency</b>	<b>Percent (%)</b>	<b>Cumulative Percent</b>
	3	90	84.9	84.9
	2	16	15.1	15.1
	Total	106	100	100
<b>Developer's Reputation</b>				
<b>Valid</b>	<b>Ranking</b>	<b>Frequency</b>	<b>Percent (%)</b>	<b>Cumulative Percent</b>
	4	106	100	100

Refers to table 3, most of the respondents were rate for location and accessibility as the first (1<sup>st</sup>) ranking that need to be considered before buying a house. It shows about 98.1% represents 104 out of 106 respondents' rates for this feature is the most important one and only 2 respondents will look into location and accessibility as their second choice. After looking at the location, most of the respondents would be looking forward to the facility before purchasing a house. The table above shows that there are 90 respondents represent the second-highest percentage with 84.9%. The physical environment as a third (3<sup>rd</sup>) ranked. It shows 84.8% represents has been the rate for this feature and 15.1% represent only 2 respondents' rate these features as second-ranking. Clean, healthy environments are important for people's physical and emotional well-being. At a fundamental level, factors such as clean air are vital to people's physical health. Other environmental causes, such as noise pollution, can cause both physical and psychological harm. The developer's reputation is the fourth (4<sup>th</sup>) ranking that has been selected by the respondents. The table above shows that 100% has been rate this feature as the last for their consideration in purchasing a property.

So, from the result above, other than location, it can be seen that green spaces are an essential element of urban neighbourhoods and make a profound contribution to the quality of life of communities. They offer many economic, social and environmental benefits. Approaching their planning and management strategically will maximise the value of capital investment and revenue expenditure. Its benefits include illustrating the contribution to health agendas (eg. reducing stress levels, by providing formal and informal recreational facilities), raising air quality and moderating extremes of temperature, protecting and enhancing levels of biodiversity and ecological habitats, providing environmental infrastructure to improve water quality and flood control and it can improve physical and social inclusion including accessibility, particularly for young, disabled and older people.

## CONCLUSIONS

In a nutshell, this research has addressed how recreation areas could influence property values or house prices. From the research findings, it can be inferred that the green spaces have many advantages and have many functions, no matter where it is situated, whether in rural areas, industrial areas, or the like. It can be seen how green spaces would attract property buyers, which the respondents thought would increase the demand for green space properties. That is because green spaces will minimise their energy usage, save resources or have a positive impact on the environment, it's good to see that tenants consider the greenness of a building an important factor in their rental decision. Most buyers naturally prefer 'green' spaces with shady streets and lush gardens with large trees. In addition, trees can help cool their homes and protect them from strong winds, provide habitat for birds and beneficial insects. Environmentally friendly landlords may find themselves in high demand after recent research has shown that many tenants consider how environmentally friendly a building is when choosing a home, particularly those paying higher rents. These green spaces not only provide a range of outdoor activities, but also control the ambient temperature. In addition, green spaces, including gardens built on water and walls, have provided an effective solution to pollution in the area. Green spaces are important to a balanced lifestyle. Next, they exude a pleasant feeling, abundant in flora and vibrant colours. They give out pure oxygen because of the greenery. Moreover, with the city's buildings rising, there is now a shortage for open spaces. Green zones, such as gardens and parks,

also provide space for homeowners to socialise. They are also venues for informal events and provide a space for people to engage in recreational activities. Gardens and parks also act as a breathing space for senior citizens in society. From jogging to yoga and other fitness activities, residents can participate in a number of fitness regimens. Not only the elderly, but these green zones also give children the opportunity to take part in group activities away from the cages of smartphones. This finding may reflect the local context of the Malaysian community did not regard the importance of recreation areas in contributing to the house price even though experiences from other international cities recorded that the relationship could be considered as strong. Empirical findings indicate that the chosen construction of areas next to public spaces would increase the local tax base resulting from the capitalization factor for housing prices. In this regard, the economic impact in terms of increased housing values on which additional property taxes can be levied is an important policy aid. Property developers and city planners can also preserve or enhance property value by considering the type, size, and distance of housing to open space. For urban planning, these facilities are important for economic development decision-making and should be recognized as an integral part of understanding issues related to the growth of the highest and best use, urban sprawl and containment. The relationship and benefits of important social amenities, such as open spaces, are habitually understated or underutilized by urban planning policymakers. The findings also show that prospective buyers and residents appear to appreciate the function of green spaces. This understanding can also aid developers in the justification of greening projects and incorporating more green space into new residential development areas. Estimates of the effect of parks on home selling prices may be useful knowledge for municipal parks and recreation agencies looking to support the ongoing purchase of land in rapidly rising areas.

## **ACKNOWLEDGEMENTS**

The authors wish to express gratitude to the house residents and other related bodies involved in this research. This paper is produced from an initial background study which is part of research funded by Faculty of architecture, Planning & Survey (FAPS) University Teknologi MARA (UiTM).

## **REFERENCES**

- [1] Anderson, S. T., & West, S. E. (2006). Open space, residential property values, and spatial context. *Regional Science and Urban Economics*, 36(6), 773–789. doi:10.1016/j.regsciurbeco.2006.03.007
- [2] Bolitzer B and N Netusil. 2000. The impact of open space on property values in Portland, Oregon. *Journal of Environmental Management*, 59: 185-193.
- [3] Crompton, J. L. (2005). The impact of parks on property values: empirical evidence from the past two decades in the United states. *Managing Leisure*, 10, 203–218.
- [4] Crompton, J.L. (2001). The impact of parks on property values. *Parks and Recreation*, May, 90-95.
- [5] Department of Town and Country Planning (2005). *Garis Panduan Piawaiian Perancangan Tanah Lapang dan Rekreasi (JPBD 7/2000)*. Ministry of Housing and Local

- Government, Peninsular Malaysia, Kuala Lumpur.
- [6] Enger, S. C. (2005). Planning for Parks, Recreation, and Open Space in Your Community. Interagency Committee for Outdoor Recreation.
  - [7] Freeman A M. 1979. Hedonic prices, property values and measuring environmental benefits: a survey of the issues. *Scandinavian Journal of Economics*, 81: 154-171
  - [8] Hui E C M, Chau C K, Pun L L, et al. 2007. Measuring the neighboring and environmental effects on residential property value: using spatial weighting matrix. *Building and Environment*, 42: 2333-2343.
  - [9] Luttik J. 2000. The value of trees, water and open space as reflected by house prices in the Netherlands. *Landscape and Urban Planning*, 48: 161-167.
  - [10] Millward, A.A. and Sabir, B. (2011) Benefits of a Forested Urban Park: What Is the Value of Allan Gardens to the City of Toronto, Canada? *Landscape and Urban Planning*, 100, 177-188. <https://doi.org/10.1016/j.landurbanplan.2010.11.013>
  - [11] Mohd H.R., Nurzuliza J., Ismail S. (2012) Urban Green Space Design Affects Urban Residents Interaction, 68 (2012) 464-480
  - [12] Morancho, A. B. (2003). A hedonic valuation of urban green areas. *Landscape and Urban Planning*, 66(1), 35-41. [https://doi.org/10.1016/S0169-2046\(03\)00093-8](https://doi.org/10.1016/S0169-2046(03)00093-8)
  - [13] Neuman, W. (2003). Social Research Method: Qualitative and Quantitative Approaches. 5th Edition. Boston.
  - [14] Netusil N R, E Boyd, Z Van Griffen, M LaMerrill, E Rainsberger. 2000. Can open space be self-financing? *Food, Farm & Resource Issues*, 15(2): 21-23
  - [15] Nicholls S, J L Crompton. 2005. The impact of greenways on property values: evidence from Austin, Texas. *Journal of Leisure Research*, 37(3): 321-341.
  - [16] Nikolaos, K., Dimitra, V., & Agapi, X. (2011). Real estate values and environment: A case study on the effect of the environment on residential real estate values. *International Journal of Academic Research*, 3(1), 861-868
  - [17] Rung, B. A. L., Mowen, A. J. and Cohen, D. A. (2005). The significance of parks to physical activity and public health. A conceptual model. *American Journal of Preventive Medicine*, 28(2S2), 159-168.
  - [18] Sasidharan, V., Yarnal, C., Yarnal, B. and Godbey, G. (2001). Climate change: What does it mean for parks and recreation management? *Parks and Recreation*, 36(3), 54-60.
  - [19] Tyrvaenen L. 1997. The amenity value of the urban forest: an application of the hedonic pricing method. *Landscape and Urban Planning*, 37: 211- 222. Tyrvaenen L and A Miettinen. 2000. Property prices and urban forest amenities.
  - [20] Waits, J. (2008). Urban green space: Is it the next financial frontier. *Business Perspectives*, 19(3), 36-39.
  - [21] Walker, C. (2004). The public value of urban parks. Retrieved February 20, 2020 from <http://scholar.google.com.my/scholar>

## **THEORETICAL FRAMEWORK AND FUTURE DIRECTIONS OF GREEN HUMAN RESOURCE MANAGEMENT ON EMPLOYEE ENGAGEMENT**

A. Vinothini

Faculty of Business, Multimedia University  
75450 Melaka, Malaysia,  
Email: vinothini.apoo@mmu.edu.my  
Phone: +6062523496

### **ABSTRACT**

In today's era, companies are competing for talent and it is becoming a challenge for companies to attract and retain talents. Employee engagement can give positive outcomes to an organisation's overall performance. Nevertheless, due to so many variables that can influence employees' engagement; it presents a challenge to determine which factors should be given more focus and attention. Despite of that, "green living" has become increasingly popular nowadays and the way of living sustainably has to be practiced every day. This is because we are in a situation where our earth's resources are getting exhausted at a rate which surpasses the replenishment rate of resources. Green human resource management is much needed in organisations. By implementing green human resource management practices, organisations will be able to protect the environment. In return, this will give them a better brand image by portraying it as being socially responsible. Hence, it can attract more customers, eventually improving the organisation's financial performance as well. Lack of understanding of the influence of employee engagement may cause decision-makers in organisations to lack the ability to take appropriate actions to improve employees' engagement and performance in their organisation. Hence, the objective of this study is to investigate the influence of green human resource management practices on employee engagement with the moderating effect of transformational leadership in SMEs in Malaysia. This study aims to provide insights for managers to enhance employee engagement by identifying the green human resource factors that may influence employee engagement. On the other hand, this research is conducted to provide exposure to employers and their employees so that they will be more sensitive to the environmental issues.

**Keywords:** employee engagement, green human resource management, transformational leadership

### **INTRODUCTION**

These days, "employee engagement" refers to a common word for organisations and workers in Malaysia. Employers assert they are doing their best in motivating employee engagement, in the meantime numerous workers still carry on to complaint that they are not being engaged towards their job. People are important assets of an organisation. It is impossible for the organisation to function without people. Therefore, employees' support towards the organisation is very

important for the organisation to achieve its goals, strategies, missions and visions. Without this support it is impossible for the organisation to have high performance and to achieve greater productivity. For achieving the organisation's objectives, strategies, missions and visions, it is important for the employees to have commitment towards their job and the organisation as a whole (Macey & Schneider, 2008; Markos & Sridevi, 2010; Rich, Lepine, & Crawford, 2010). Organisations needed the support of their HR systems to enable them to be more environmentally friendly (Charbel José Chiappetta Jabbour & De Sousa Jabbour, 2016; Khurshid & Darzi, 2016). Hence, different approach to Human Resource Management (HRM) has progressed (Mandip, 2012). This new approach is known as "sustainable Human Resource Management". This approach refers to the linkage of HRM and sustainability. However, "sustainable HRM" is not a new term, it has been around for more than ten years. This term has been used in many different means. It was used to mention social and human outcomes which contributes to sustainable company. Other than that, it is also used to mention HRM activities that contributes to positive environmental outcomes, which is known as Green human resource management (GHRM) (Kramar, 2014).

Regardless of the increasing trend ever since 2012, employee engagement (EE) levels in Malaysia has dropped to 59 percent, based on the "2017 Trends in Global EE Report" from Aon, a top global professional services organisation that offers variety of solutions such as health, risk, and retirement. Based on the figure below, it shows that Malaysia still ranks between the lowest in the region, having lesser EE percentage compared to other neighbouring countries such as Indonesia and Philippines.



**Figure 1.** Employee Engagement Scores.

The problems faced by Malaysian SMEs such as employee turnover and low performance will cause the sector to be less competitive and may thwart good performance (Ghani, Kaliappen, & Jermisittiparsert, 2019; Haruna & Marthandan, 2017). It has always been a challenge for SMEs to keep their employees for a long term because of the size and lack of focus on managing employees (Wee, 2013). In a recent research conducted in Malaysia by Ghani et al., (2019, p.3), it is stated that "employee low work engagement has become the critical issue that needs to be resolved".

Salanova, Agut, Peiro, Salanova, & Agut (2005), Suan & Nasurdin (2014) and Tangthong, Trimetsoontorn, & Rojniruntikul (2014) mentioned that "HRM components play a strong role towards EE". In reality, very limited studies are found drawing the relationship of HR practices on EE (Salanova et al., 2005; Suan & Nasurdin, 2014), especially Green HRM. In contrast to this, it has been stated by previous researchers such as Ahmad (2015), Jabbour & Santos (2008)

and Renwick, Redman, & Maguire (2013) that talented employees can be retained through green or environmental implementations in the organisation. This has been supported by Aggerholm et al., (2011) and Ooi (2017), stating that companies which take into consideration the impacts on the environment by the means of HRM practices will have competitive advantage over their rivals. Given the importance people place on the environment and sustainability and HRM practices, it triggered the needs to investigate whether Green HRM practices may improve employees' engagement in SMEs.

Therefore, through some adaptations of the works by Cheema et al (2015), (Jia, Liu, Chin, & Hu, 2018), as well as (Ghafoor, Qureshi, Khan, & Hijazi, 2011) this study has formed its specific research framework. The independent variables are based from the research done by Cheema, Pasha, & Javed (2015). Cheema et al (2015), stated that the best models of GHRM includes recruitment, selection, training and development, performance appraisal and compensation. The moderating variable has been selected based on the findings that transformational leadership has influence towards GHRM and EE (Ghafoor et al., 2011; Jia et al., 2018).

## **LITERATURE REVIEW**

### **Employee Engagement (EE)**

Employee Engagement (EE) is about being passionate and committed to the organisation to help the organisation succeed (Macey & Schneider, 2008). EE gained its attention about twenty years ago. In the beginning, employers focused on employee satisfaction. Locke (1976), defines job satisfaction as "a pleasurable or positive emotional state resulting from the appraisal of one's job or job experiences", this has been commonly used in the research conducted during 1970s. Others have defined it as simply how pleased or satisfied an individual is towards their work; whether that person likes the work or not (Abou-Zaki, 2003). It has been noted by researchers that job satisfaction can be measured in two different contexts; feelings an individual has towards their work and cognition about the work. This is known as affective and cognitive job satisfaction (Kalleberg, 1977; Wright, 1997). Employers believed that employees who are pleased will eventually result in enriched process, improved productivity, and overall it will produce a better working environment. However, this proves not to be necessarily the case. For example, when employers allow their staffs to make calls that are personal and not work related while these staffs are working, allowing staffs to have conversation with their colleagues rather than finishing their work related tasks, and come to work late, might express job satisfaction but these behaviours does not bring benefits to the organisation.

When focus on job satisfaction was not very fruitful for organisations, they moved towards paying attention to the commitment of employees. Employers desired to decrease their turnover rate by focusing on improving their employees' faithfulness towards the organisation. The similarity of individual goals and the goals of the company can be defined as employee commitment. In which, the individual is able to identify with the company goals and he or she puts in effort in achieving the goals. There are differences between commitment and satisfaction. Commitment refers to a more global response towards a company. However, satisfaction in terms of work refers to an individual response to a specific work otherwise numerous aspects of the work (Bhatti & Qureshi, 2007). This is also supported by (Wiener, 1982), whereby job satisfaction is referred to as an attitude concerning the conditions and aspects of the work. Thus, commitment proposes the attachment of the employee towards the company compared to



specific jobs, environmental features, as well as the place where the jobs are done (Bhatti & Qureshi, 2007).

Certain behaviours tend to display commitment. For instances, individuals who spends their time and energy to complete various responsibilities which includes work, family and personal, it shows their commitment towards it. Commitment has emotional and rational component. Emotional component is generally, when an individual tend to express positive feelings to a thing or other people whom they are committed to. Rational element is when it involves thinking carefully and then executing the actions to fulfil their commitments. Nevertheless, commitment cannot be guaranteed by using a single way. For example, when the economy is going through a difficult time, companies have no choice but to lay off their workers. However, these workers realised that they will have to seek for better opportunity rather than just being loyal to one company.

Therefore, to have better employee commitment towards their work and organisation, EE came into the picture. Organisations become aware that when employees are given important role in the organisation in terms of the job, their loyalty towards the organisation tend to increase as well their performance and satisfaction. When the staffs in an organisation feel a connection with the organisation, they will strive to give their best for the organisation. EE has developed as a means for companies to measure their investment in human resource; which serves as a further alternative to measure the commitment of staffs towards the company and for creating an effective workplace (Echols 2005).

### **Green Human Resource Management (GHRM)**

Over the years, there has been many improvements done towards Human Resource Management (HRM) and nowadays there is a need for going beyond HRM (Kramar, 2014; Sharma, 2016). Many researchers have started exploring the new approach towards a more sustainable HRM (Kramar, 2014; Rajiani, Musa, & Hardjono, 2016).

The focus of HRM has shifted from just focusing on economic growth and employees' current needs to protecting the natural environment as a whole for the benefits of current and as well as future generations (Kanwal, 2016; Wagner, 2013). Due to this shift, the term HRM has evolved to GHRM. This approach looks for the connection between HRM and sustainability. The focus of GHRM is basically to promote sustainable actions by creating an awareness among employees and also by building their commitment towards sustainability (Prasad, 2013; Sharma, 2016).

The GHRM development does not only include the awareness of environmental concern such as waste reduction however, it includes the degree of improvement in the economic and social well-being of the individuals along with organisations (Obaid & Alias, 2015). GHRM encompasses all those activities, practices and behaviour of the organisation which are directed towards maintaining ecological balance while carrying out various activities in human resource processes such as training and development, recruitment, performance appraisal and compensation. GHRM has emerged as a crucial area of management which can have profound impact on people working in the organisation towards addressing environmental issues (Khurshid & Darzi, 2016).

Based on the research conducted by Obaid & Alias (2015), GHRM activities such as green recruiting, green training and green development are important in creating and retaining a sustainable environment performance. In the long run, it will also improve the organisations performance and reputation as people become more aware of the organisations green initiatives. Going green should be in everybody's mind and actions. This includes an individual as well as

up to a whole organisation. Everybody should be responsible to create a sustainable environment for the future generations (Smith, 2007; Vyas, 2016).

Organisations which are involve in human resource practices that are environmentally friendly tend to have better employee engagement and retention (Opatha & Arulrajah, 2014). This is also supported by Sharmin (2015), green HRM involves undertaking environment friendly initiatives which in turn results in greater efficiency, lower costs, and better employee engagement and retention. This act can also help the organisation to reduce its carbon footprints and provide safer environment to the future generations. However, green HRM begins with the use of HRM policies to encourage the sustainable use of resources within organisations and as well as to promote the cause of environmentalism which further increases employee morale and satisfaction (Ismail & Hassan, 2020). Satisfied employees tend to be more engaged (Harter, Schmidt, & Hayes, 2002).

### **GHRM Practices**

GHRM practices refer to the real GHRM programs, processes and techniques that actually get executed in the organisations in order to reduce negative environmental impacts or increase positive environmental impacts of the organisations (Arulrajah, Opatha, & Nawaratne, 2015). These initiatives include the use of telephonic interview, communication via email which provides better efficiencies and lesser operating cost (Opatha & Arulrajah, 2014). Discovering and analysing about GHRM practices that are being practiced and are to be practiced by the business and other firms will be able to contribute significantly to the human resource management field academically and practically (Arulrajah et al., 2015). Moreover, it is able to make people of the organisation green for the benefit of the individual, society, natural environment, and the business as a whole (Opatha & Arulrajah, 2014).

### **Green Recruitment**

Green recruitment refers to the overall process of attracting, short listing, selecting and appointing suitable candidates for a job via the paperless method. For example, this includes posting job advertisements online (Vyas, 2016). Ahmad, (2015) defines green recruitment as the process of hiring individuals with knowledge, skills, approaches, and behaviours that identify with environmental management systems within an organisation.

In the “war for talent”, it has become a key human resource challenge for attracting high-quality staff (Renwick et al., 2013). Companies nowadays are starting to recognise the fact that gaining a reputation as a green employer is an effective way to attract new talent (Vyas, 2016). Based on the Survey data in the United Kingdom, it shows one of the criteria that ambitious graduates look for when they would want to decide on their job application is the environmental performance and reputation of the organisation ( Renwick, Redman, & Maguire, 2008). As stated by Mandip (2012), the CIPD (Chartered Institute of Personnel and Development) survey of 1,000 respondents shows that 47% of HR professionals believe that employees would prefer working for organisations that consume a strong green approach. However, 46% asserting that having one would actually aid in attracting potential employees. Similarly, Ismail & Hassan, (2020) stated that nowadays, more millennials would like to be hired by organisations which practices environmental management. Pursuing to this current trend, successful organisations want to retain their employees who are engaged in their work, have high level of energy and dedicated. Being able to attract and retain the right people serves as the basis of an organisation’s success.

### **Green Selection**

In terms of selection, organisations who implements “green selection” seeks for candidates who have interest in the well-being of the environment and who are environmentally concern. This becomes their main selection criteria. This is reflected in the questions the organisations ask during interviews or during the evaluation process for selecting the best candidate; they tend to ask environmental-related questions (Arulrajah et al., 2015). This is also supported by Margaretha & Saragih, (2013), stating that the interview questions should be tailored to point out the company's green goals. Companies use a number of techniques to hire the most appropriate employee for their company to help them to be able to perform successfully. The employee selection stage is vital to make sure that the selected candidate is committed to the organisation. This can be done by providing the candidate with information about the job (Gill, 2007). According to Arulrajah et al., (2015), green selection involves selecting a candidate with the interest of protecting the environment.

### **Green Training and Development**

Employers need to understand that the training and development they extend to all their employees – and especially to their more talented ones – will not only make them being abler and more valuable to the company, but will also act as a powerful incentive for them to stay (Woodruffe, 2006). Arulrajah et al., (2015) suggests that providing environmental training to the company’s managers and employees who are non-managerial members in order to create the required skills and knowledge is a crucial function of GHRM. Green training includes providing online courses to improve employees’ skills and to enhance employee development without endangering the environment. These green activities help to preserve the natural environment (Vyas, 2016). Training and development is an important variable to take into account while considering the process of engaging workers. This is because it aids the workers to be able to focus more towards their work. The study conducted by Anitha, (2014) reported training as well as career development as one of the main sources for organisations to create a pool of engaged employees. Employees from lower and middle managerial levels from “small-scale companies” has been selected for the study. A sum of 383 valid responses were obtained. Based on the findings, it shows that training and development affect EE. Similarly, the findings of the research carried out by Uraon (2018), indicate that HR development practices have a positive influence on employees’ intention to remain in an organisation as well as being committed to the organisation. This is also supported by June (2011); training and development is an important variable to take into account while considering the process of keeping workers engaged. This is because it aids to solve problems faced by SMEs such as low productivity due to lack of right skills.

### **Green Performance Management**

Performance management refers to the process by which employees in an organisation are impelled to enhance their professional skills that can help to achieve the overall organisational goals and objectives in an improved way. With the environmental management affecting global business strategy, performance management is also being influenced by the green wave in a positive way. Green performance management consists of issues related to environmental concerns and policies of the company (Ahmad, 2015). Measuring employee green performance of job is one of the key functions in GHRM. Without this practice any organisation cannot ensure the realistic environmental performance (firm level) in long term basis (Arulrajah et al., 2015).

Based on the concept of “performance management”, it is believed that an organisation’s commitment is dependent on employees’ performance management (Asamany & Shaorong, 2017). This is proven in the study that has been conducted on 180 employees (staffs and management) of thirty-eight SMEs located in the Greater Accra region of Ghana. The findings of the study state that the performance management system has influence on organisational commitment (Asamany & Shaorong, 2017). Besides, contributing to organisational commitment, according to Mone, Eisinger, Guggenheim, Price, & Stine (2011), “it appears that performance management may be used to increase the levels of employee engagement”. Similarly, Mokaya & Kipyegon (2014) mentioned that a strong performance management system is able to hold attention of top performing employees to reduce the turnover rate.

### **Green Compensation and Benefits**

One of the major part of human resource management is compensation and benefits. This is where employees get rewarded for their performance. It is also a powerful technique for linking together an employee’s interest to the interest of the organisation. Compensation and benefits play an important role in motivating employees to perform well in their work and in achieving organisational goals (Ahmad, 2015).

Organisations can practice green compensation and benefits in two ways; monetary and non-monetary. This green compensation and benefits serve as a significant function of GHRM. The sustainability of the firms’ environmental performance is highly reliant on the green compensation and benefits management practices of the firms. In the aim to motivate managers and non-managerial employees on corporate environmental management initiatives, green compensation and benefits management has major contributions (Arulrajah et al., 2015). Compensation and benefits are a crucial element to EE that can motivate workers to attain more and therefore concentrate better on their job and self-development. After conducting a study on employees (lower and middle managerial levels) from “small-scale companies”, Anitha (2014) concluded that compensation contributes to EE.

### **Transformational Leadership**

For an organisation to be responsible to the people and the environment begins with understanding top leaders’ or managers’ traits, values, and characteristics. This reflects the choices taken for the organisation and the practices within the organisation (Jones Christensen, Mackey, & Whetten, 2014). Effective leaders tend to be different in beliefs, values and personalities. They have their own strengths and weaknesses. Nevertheless, they all have one thing in common; it is the ability to do the right things at the right time. Their contributions are vital in the long term development of the institution and people to enable them to adapt change and grow (Green & McCann, 2011). Previous studies show that transformational leadership is able to influence employee engagement. For example, Tims et al, (2011) stated that daily transformational leadership is related positively to employees' daily engagement. Echoing this, Amor (2020) noted that “transformational leadership is related positively to work engagement. Past researchers have also supported that an employee who receives support, inspiration and quality coaching from their supervisor, is more likely to become highly engaged with the job tasks (Tims et al., 2011).

Transformational leadership indirectly affects others’ behaviour especially when leaders share values with their followers, convince followers that they can achieve the targets which they thought they are unable to achieve, help employees think in new and innovative ways and as well

as to establish a relationship through which they can exert an influence on certain behaviours (Jones Christensen et al., 2014). In addition to this, transformational leadership includes forming a vision and communicating it to their followers. In this communication process, human resource management plays a vital role between the leader and their followers. Therefore, in order to make the vision a reality, leaders have to rely on human resource management (Loshali & Krishnan, 2013). (Burns, 1979, p. 21) cited in (Ghadi, 2017) defines transformational leadership as “the process through which leaders and followers help each other to advance to a higher level of morality and motivation”. This research recommends that transformational leadership plays a moderating role between GHRM practices “recruitment, selection, training and development, compensation, and performance management” as well as EE. In this study, several lines of argument support the expectation of a positive relationship. Jia, Liu, Chin, & Hu (2018) applied transformational leadership in their research to influence green HRM and their findings prove that leaders can leverage transformational behaviours in the early stages of GHRM development to establish norms for cooperation. Ghafoor et al (2011) stated that when transformational leadership is strong it can develop employee engagement.

### **Research Gaps**

Most of the previous studies on EE explored the construct of EE which includes identifying and understanding the meaning of EE (Desai et al., 2010; Johnson, 1939; Meyer & Gagne, 2008). Apart from that, there were researches who carried out their research on the antecedents and consequences of EE (Burke, Koyuncu, & Fiksenbaum, 2013; Ram, 2011; Rasheed & Khan, 2013; Rich et al., 2010; Saks, 2006). For example, in the research conducted by Saks (2006), “job characteristics, perceived organisational support, perceived supervisor support, rewards and recognition, procedural justice and distributive justice has been identified as the antecedents of EE; on the other hand, job satisfaction, organisational commitment, intention to quit and organisational citizenship behaviour has been identified as the consequences of EE”.

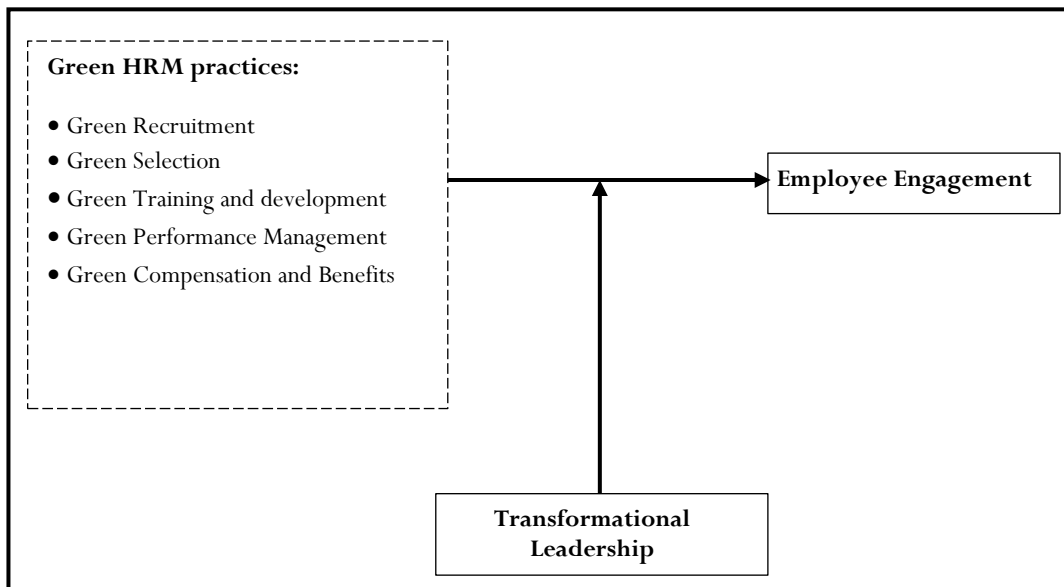
There were researches that has been conducted on the factors or the drivers of EE (Castellano, 2009; Robinson, Perryman, & Hayday, 2004; Sundaray, 2011). In the study conducted by Johari, Adnan, Yean, KiranaYahya, & Isa (2013), they examined EE through HR practices in manufacturing companies in Malaysia. Based on their findings, it is stated that monetary and non-monetary recognition as well as fringe benefits on EE has a significant and positive impact. Anitha (2014), included “work environment, leadership, team and co-worker, training and career development, compensation, organisational policies and workplace well-being” as the determinants of EE. Based on her findings, all the identified elements are able to predict EE. Most of the previous studies on EE paid less focus on GHRM. Existing GHRM literature focuses mainly on western, however, based on the importance of environmental management in the development of Asian economy, this is a key gap to be identified by future researchers (Ahmad, 2015). GHRM can play an essential role in making organisations environment friendly. Organisations which address green concerns and take green initiatives are likely to experience competitive advantage in the form of improvised company and brand image. Organisations that are green conscious will be viewed as a responsible entity in the market (Khurshid & Darzi, 2016).

Nevertheless, researchers up to date has tried to look into few areas related to green such as green marketing (Arminda, 2009; Kirchoff, Koch, & Nichols, 2011), green supply chain (Hsu & Tan, 2012; Zhu & Sarkis, 2000), green system (Road & Kingdom, 2013) and green finance (Abdur, 2012; Ooi, 2017). However, less attention has been paid to GHRM and its concept and

practices remains unclear (Renwick, Redman, & Maguire, 2013). Especially on the influence of GHRM towards EE.

Hence, the practices under GHRM is worth to be explored (Jackson, Renwick, Jabbour, & Muller-Camen, 2011). Thus, this study is conducted to identify the major GHRM practices which actually have the impact towards employees' engagement.

## RESEARCH FRAMEWORK



**Figure 2.** Research Framework

The above framework has been developed based on intensive literature reviews, incorporating all possible factors which are believed to be highly relevant to the success of improving employee engagement in SMEs in Malaysia. The framework consists of three important categories of variables. They are the "dependent variable", "independent variables" as well as "moderating variable". The dependent variable in this study is Employee Engagement. The independent variables consist of five important HRM practices that could contribute and affect EE. These variables are known as "green recruitment", "green selection", "green training and development", "green performance management" and "green compensation and benefits". Lastly, the moderating variable consists of transformational leadership.

With reference to figure 2, this research study puts forward different types of existing theories on examining employee engagement among employees in SMEs in Malaysia. The dependent variable "employee engagement" is derived from self-determination theory. The independent variables are selected from AMO theory and the moderating variable has been selected from social exchange theory. The primary intention of this research is to make a contribution to increase EE in SMEs by investigating the selected variables from the theory that emerged from the literature.

Self-determination theory research has constantly revealed that individuals who are "engaged" in what they are doing also tend to experience greater psychological and physical well-being compared to those who are lack of personal control. The well-being of employees is significant

and tend to bring benefits for organisation as whole. For example, lower absenteeism and reduced costs of health insurance.

Five GHRM practices has been chosen for this study as the independent variables by using “Ability-Motivation-Opportunity (AMO) theory”. This theory remains as the most regularly applied conceptualisations of the influence of HRM practices on organisational performance in empirical studies (Renwick et al., 2013). Based on this theory, HRM works via growing workers’ Ability by attracting, selecting as well as by developing top performing talents. Followed by improving workforces’ Motivation through compensation and benefits and via effective management of performance. Finally, giving staffs the Opportunity to involve in sharing knowledge as well as problem solving activities. Based on the study conducted by Cheema et al (2015), “the best models of GHRM includes recruitment, selection, training and development, performance appraisal and compensation”. The reason these variables has been selected for this study is because employees’ perception of GHRM in employees’ properties generally enhanced their commitment to their organisations. Moreover, recruitment is one of HRM’s best practices that is expected to influence the performance of a firm in a positive manner (Cheema et al., 2015; Joong, Gon, Choi, & Phetvaroon, 2019). Anitha (2014), are among the researchers who linked some of the human resource practices towards EE. In the research conducted by Anitha (2014), training and development as well as compensation and benefits are among those factors that has been selected and examined for employee engagement.

Social exchange theory is used to provide a theoretical basis for explaining the leadership style that has been accepted by followers and the structural empowerment might affect an individual’s engagement towards his or her job. This theory clarifies “social exchange as a process of negotiated exchanges between parties that entail reciprocity”. This is to say, when leaders and followers’ bond are shaped, a type of mutual commitments will be produced, for instance “psychological meaningfulness, safety or availability when leaders show genuine personal recognition or supportive leadership” (Amor, 2020). Ghafoor et al (2011) stated that EE is developed when transformational leadership is robust. On the other hand, Jia, Liu, Chin, & Hu (2018) stated that transformational leadership has influence towards GHRM. Therefore, this study would like to investigate if there is any moderating effect of transformational leadership towards GHRM and EE.

## **CONCLUSION**

In conclusion, the findings of this study is believed to be beneficial in a ‘practical’ and ‘theoretical’ perspective. This research is conducted in a hope that the findings of this research will provide a deeper understanding on the elements that would influence EE at workplace. The outcome of this research will be beneficial to the managers of the organisations as it will be able to provide them with insights on the factors which will influence employees to be engaged to their job and enable them to analyse critically the methods which will be most effective in improving the employees’ engagement and at the same time to improve the company’s performance. Therefore, it will be able to reduce the overall turnover rate of employees in SME companies. On the other hand, this research is conducted to provide exposure to organisations as well as their employees so that they will be more sensitive to the environmental issues. By implementing green human resource management practices, organisations will be able to protect the environment. In return, this will give them a better brand image by portraying it as

being socially responsible. Hence, it can attract more customers, eventually improving the organisation's financial performance as well. The current understanding on what contributes to EE is still vague. Therefore, in terms of theoretical significance, this research wishes to fill the gap in terms of identifying the factors which contributes to EE by addressing the issues in Malaysian context and analysing the factors which influence employees' intention to be committed to their job. Moreover, this research aims to help in increasing the knowledge that has already existed. It also helps to resolve the lack of practical research on the contributing factors towards EE in Malaysian SMEs, and draws important and practical conclusion. Research topics on EE in SMEs in Malaysia is still in its infant stage due to limited research has been carried out in the past. The reason this topic has limited research and empirical evidence, especially in Malaysia, is due to most of previous researches were focus on other factors contributing to EE less focused was given on green human resource practices (Arrowsmith & Parker, 2013; Freeney & Tiernan, 2012; Konrad, 2006; Saks, 2006; B. Shuck & Wollard, 2010; Brad Shuck, Reio, & Rocco, 2011; van Rooy, Whitman, Hart, & Caleo, 2011). However, this study focuses primarily on the influences of GHRM practices towards EE in SMEs in Melaka, Malaysia. In theoretical perspective, this study contributes to a deeper understanding of how GHRM practices can affect EE in SMEs in Malaysia. It contributes to the number researches in the management field, especially in terms of GHRM practices. This study may assist other researchers for further investigation in this area of study as not many researches have been carried out in Malaysia. In addition, this study also enables future researchers to make references for their work on the relevant topic.

## REFERENCE

- [1] Abdur, K. Green microfinance promoting green enterprise development. *International Journal of Research Studies in Management*. 2012;1(1):85–96.
- [2] Abou-Zaki, B & Crossman, A. Job satisfaction and employee performance of Lebanese banking staff. *Journal of Managerial Psychology*. 2003;18(4):368-376.
- [3] Aggerholm, H. K, Andersen, S. E, & Thomsen, C. Conceptualising employer branding in sustainable organisations. *Corporate Communications*. 2011;16(2):105–123.
- [4] Ahmad, S. Green human resource management: Policies and practices. *Cogent Business and Management*. 2015;2(1):1–13.
- [5] Amor, A. M. Transformational leadership and work engagement: Exploring the mediating role of structural empowerment. *European Management Journal*. 2020;38:169-178.
- [6] Anitha, J. Determinants of employee engagement and their impact on employee performance. *International Journal of Productivity and Performance Management*. 2014;63(3):308-323.
- [7] Arminda, R. "Green" segmentation :an application to the Portuguese consumer market. *Marketing Intelligence and Planning*. 2009;27(3):364–379.
- [8] Arrowsmith, J & Parker, J. The meaning of ' employee engagement ' for the values and roles of the HRM function. *The International Journal of Human Resource Management*. 2013;24(14), 2692–2712.
- [9] Arulrajah, A. A., Opatha, H. H. D. N. P., & Nawaratne, N. N. J. Green human resource management practices : A review literature review on green HRM practices. *Sri Lankan Journal of Human Resource Management*. 2015;5(1):1–16.



- [10] Asamany, A & Shaorong, S. The ripple effects of performance management on employees' perceptions and affective commitment among small and medium scale enterprises (SMEs). *International Journal of Business Administration*. 2017;9(1):55.
- [11] Bhatti, K. K, & Qureshi, T. M. Impact of employee participation on job satisfaction , employee commitment and employee productivity. *International Review of Business Research Papers*. 2007;3(2):54–68.
- [12] Burke, R. J., Koyuncu, M., & Fiksenbaum, L. Antecedents and consequences of work engagement among frontline employees in Turkish hotels. *Journal of Transnational Management*. 2013;18(3):191-203.
- [13] Castellano, W. G. A new framework of employee engagement. *Rutgers Center for Human Resource Strategy*. 2009;26.
- [14] Cheema, S, Pasha, A. T, & Javed, F. Green human resource practices: Implementations and hurdles of SMEs in Pakistan. *Journal of Business Studies*. 2015;7(2):231–241.
- [15] Desai, M, Majumdar, B, & Prabhu, G. P. A study of employee engagement in two Indian businesses. *Asian Journal of Management Research*. 2010;81–97.
- [16] Freeney, Y., & Tiernan, J. Employee engagement: an overview of the literature on the proposed antithesis to burnout. *The Irish Journal of Psychology*. 2012;27(3–4): 130–141.
- [17] Ghadi, M. Y. Transformational leadership and work engagement : The mediating effect of meaning in work. *Leadership & Organisation Development Journal*. 2017;34(6):532-550.
- [18] Ghafoor, A., Qureshi, T.M., Khan,M.A, & Hijazi, S.T. Transformational leadership, employee engagement and performance: Mediating effect of psychological ownership. *African Journal of Business Management*. 2011;5(17):7391–7403.
- [19] Ghani, A.B.A., Kaliappen, N., & Jermisittiparsert, K. Enhancing Malaysian SME employee work engagement: The mediating role of job crafting in the presence of task complexity, self-efficacy and autonomy. *International Journal of Innovation, Creativity and Change*. 2019;6(11):1–18.
- [20] Gill, D.S. Employee selection and work engagement: Do recruitment and selection practices influence work engagement? 2007; 1–79.
- [21] Green, D.D., & McCann, J. Benchmarking a leadership model for the green economy. *Benchmarking: An International Journal*. 2011;18(3):445–465.
- [22] Harter, J. K., Schmidt, F. L., & Hayes, T. L. Business-unit-level relationship between employee satisfaction, employee engagement, and business outcomes: a meta-analysis. *The Journal of Applied Psychology*. 2002;87(2):268–279.
- [23] Haruna, A.Y, & Marthandan, G. Foundational competencies for enhancing work engagement in SMEs Malaysia. *Journal of Workplace Learning*. 2017;29(3):165–184.
- [24] Hsu, C., & Tan, K. C. Supply chain drivers that foster the development of green initiatives in an emerging economy. *International Journal of Operations & Production Management*. 2012;33(6):656-688.
- [25] Ismail, I., & Hassan, R. Employee and top management engagement as main determinants of successful green HRM. *International Journal of Business and Economy*. 2020;2(1):20–24.
- [26] Jabbour, Charbel José Chiappetta, & De Sousa Jabbour, A. B. L. Green human resource management and green supply chain management: Linking two emerging agendas. *Journal of Cleaner Production*. 2016;112:1824–1833.

- [27] Jabbour, Charbel Jo   Chiappetta, & Santos, F. C. A. The central role of human resource management in the search for sustainable organisations. *International Journal of Human Resource Management*. 2008;19(12):2133–2154.
- [28] Jackson, S. E., Renwick, D. W. S., Jabbour, C. J. C., & Muller-Camen, M. State-of-the-art and future directions for green human resource management. *German Journal of Research in Human Resource Management*. 2011;25(2):99–116.
- [29] Jia, J., Liu, H., Chin, T., & Hu, D. The continuous mediating effects of GHRM on employees' green passion via transformational leadership and green creativity. *Sustainability*. 2018;10:3237.
- [30] Johari, J., Adnan, Z., Yean, T.F., KiranaYahya, K., & Isa, S. N. Fostering employee engagement through human resource practices : A case of manufacturing firms in Malaysia. *Jurnal Pengurusan*. 2013;38:15–26.
- [31] Johnson, P.R. *Journal of organisational culture, communications and conflict*. Communications.1939;10(1):113.
- [32] Jones Christensen, L., Mackey, A., & Whetten, D. Taking responsibility for corporate social responsibility: the role of leaders in creating, responsible firm behaviors. *The Academy of Management Perspectives*. 2014;28(2):164–178.
- [33] Joong, Y., Gon, W., Choi, H., & Phetvaroon, K. The effect of green human resource management on hotel employees' eco-friendly behavior and environmental performance. *International Journal of Hospitality Management*. 2019;76:83–93.
- [34] June, S. The relationship between person-job fit and job performance : A study among the employees of the service sector SMEs in Malaysia. *International Journal of Business, Humanities and Technology*. 2011;1(2):95–105.
- [35] Kalleberg, A.L. Work values and job rewards: A theory of job satisfaction. *American Sociological Review*. 1977;42(1):124–143.
- [36] Kanwal, S. The effect of green HRM practices on sustainability: Evidence from manufacturing companies in Pakistan. *Pakistan Journal of Social Sciences*. 2016;36(1):177–188.
- [37] Khurshid, R., & Darzi, M.A. Go green with green human resource management practices. *International Journal of Research in Commerce and Management*. 2016;7(1):19–21.
- [38] Kirchoff, J. F., Koch, C., & Nichols, B. S. Stakeholder perceptions of green marketing: the effect of demand and supply integration. *International Journal of Physical Distribution & Logistics Management*. 2011;41(7):684-696.
- [39] Konrad, A. M. Engaging employees through high-involvement work practices. *Ivey Business Journal*. 2006;70(4):1–6.
- [40] Kramar, R. Beyond strategic human resource management: is sustainable human resource management the next approach? *International Journal of Human Resource Management*. 2014;25(8):1069–1089.
- [41] Loshali, S. & Krishnan, V.R. Strategic human resource management and firm performance: Mediating role of transformational leadership. *Journal of Strategic Human Resource Management*. 2013;2(1):9–19.
- [42] Macey, W.H. & Schneider, B. The meaning of employee engagement. *Industrial and Organisational Psychology*. 2008;1:3–30.
- [43] Mandip, G. Green HRM :people management commitment to environmental sustainability. *Research Journal of Recent Sciences*. 2012;1:244–252.

- [44] Margaretha, M. & Saragih, S. Developing new corporate culture through green human resource practice. *International Conference on Business, Economics, and Accounting*. 2013.
- [45] Markos, S. & Sridevi, S. Employee engagement : the key to improving performance. *International Journal of Business and Management*. 2010;5(12):89–96.
- [46] Meyer, J. & Gagne, M. Employee engagement from a self-determination theory perspective. *Industrial and Organisational Psychology*. 2008;1:60–62.
- [47] Mokaya, S.O. & Kipyegon, M.J. Determinants of employee engagement in the banking industry in Kenya;case of cooperative bank. *Journal of Human Resources Management and Labor Studies*. 2014;2(2):187–200.
- [48] Mone, E., Eisinger, C., Guggenheim, K., Price, B., & Stine, C. Performance management at the wheel: Driving employee engagement in organisations. *Journal of Business and Psychology*. 2011;26(2):205–212.
- [49] Obaid, T.F. & Alias, R.B. The impact of green recruitment, green training and green learning on the firm performance:conceptual paper. *International Journal of Applied Research*. 2015;1(12):951–953.
- [50] Ooi, S.K. Perceived importance and readiness of green HRM in Malaysian financial services industry. *Global Business and Management Research: An International Journal*. 2017;9(4):457–475.
- [51] Opatha, H.H.D.N.P. & Arulrajah, A.A. Green human resource management: simplified general reflections. *International Business Research*. 2014;7(8).
- [52] Prasad, R. Green HRM-partner in sustainable competitive growth. *Journal of Management Sciences and Technology*. 2013;1(1):15–18.
- [53] Rajiani, I., Musa, H., & Hardjono, B. Ability, motivation and opportunity as determinants of green human resources management innovation. *Research Journal of Business Management*. 2016;10(1):51–57.
- [54] Ram, P. The role of employee engagement in work-related outcomes. *Business*. 2011;1:47–61.
- [55] Rasheed, A. & Khan, S. Antecedents and consequences of employee engagement : the case of Pakistan. *Journal of Business Studies Quarterly*. 2013;4(4):183–200.
- [56] Renwick, D., Redman, T., & Maguire, S. Green HRM : A review , process model , and research agenda. *Discussion Paper: The University of Sheffield Management School*. 2008;44(0).
- [57] Renwick, D.W.S.D., Redman, T. & Maguire, S. Green human resource management: a review and research agenda. *International Journal of Management Reviews*. 2013;15(1):1–14.
- [58] Rich, B.L., Lepine, J.A., & Crawford, E.R. Job engagement: antecents and effects on job performance. *Academy of Management Journal*. 2010;53(3):617–635.
- [59] Road, S. & Kingdom, U. Green human resource management : a review and research agenda. 2013;44:0–35.
- [60] Robinson, D., Perryman, S., & Hayday, S. The drivers of employee engagement. 2004;408.
- [61] Saks, A. M. Antecedents and consequences of employee engagement. *Journal of Managerial Psychology*. 2006;21:600–619.
- [62] Salanova, M., Agut, S., & Peiro, J.M. Linking organisational resources and work engagement to employee performance and customer loyalty: the mediation of service

- climate. *Journal of Applied Psychology*. 2005;90(6):1217–1227
- [63] Sharma, K. Conceptualisation of green HRM and green HRM practices: commitment to environment sustainability. *Advanced Scientific Research and Management*. 2016;1(8):74–81.
- [64] Sharmin, S. Green HRM: an innovative approach to environmental sustainability. *Twelfth AIMS International Conference on Management*. 2015;1–15.
- [65] Shuck, B. & Wollard, K. Employee engagement and HRD: a seminal review of the foundations. *Human Resource Development Review*. 2010;9:89–110.
- [66] Shuck, Brad, Reio, T.G., & Rocco, T.S. Employee engagement: an examination of antecedent and outcome variables. *Human Resource Development International*. 2011;14(4):427–445.
- [67] Smith, B. Comments on “The parting gift.” *Thunderbird International Business Review*. 2007;49(5):630–631.
- [68] Suan, C.L., & Nasurdin, A.M. An empirical investigation into the influence of human resource management practices on work engagement: The case of customer-contact employees in Malaysia. *International Journal of Culture, Tourism, and Hospitality Research*. 2014;8(3):345–360.
- [69] Sundaray, B.K. Employee engagement :a driver of organisational effectiveness. *European Journal of Business and Management*. 2011;3(8):53-60.
- [70] Tangthong, S., Trimetsoontorn, J. & Rojniruntikul, N. HRM practices and employee retention in Thailand — a literature review. *International Journal of Trade, Economics and Finance*. 2014;5(2).
- [71] Tims, M., Bakker, A.B., & Xanthopoulou, D. Do transformational leaders enhance their followers’ daily work engagement? *Leadership Quarterly*. 2011;22(1):121–131.
- [72] Uraon, R. S. Examining the impact of HRD practices on organisational commitment and intention to stay within selected software companies in India. *Advances in Developing Human Resources*. 2018;20(1):11 –43.
- [73] Van Rooy, D.L., Whitman, D.S., Hart, D. & Caleo, S. Measuring employee engagement during a financial downturn: business imperative or nuisance? *Journal of Business and Psychology*. 2011;26(2):147–152.
- [74] Vyas, A. New era of human resource management – go green. *International Journal Of Applied Research In Science And Engineering*. 2016;189–191.
- [75] Wagner, M. “Green” human resource benefits: do they matter as determinants of environmental management system implementation? *Journal of Business Ethics*. 2013;114(3):443–456.
- [76] Wee, T. C. Talent retention : the pressures in Malaysia SMEs. *American Journal of Economics*. 2013;3:35–40.
- [77] Wiener, Y. Commitment in organisations : a normative view. *Academy of Management Journal*. 1982;7(3):418–428.
- [78] Woodruffe, C. Viewpoint the crucial importance of employee engagement. *Human Resource Management International Digest*. 2006;14(1):3–5.
- [79] Wright, T. A. Well-being, satisfaction and job performance : another look at the happy / productive worker thesis. 1997.
- [80] Zhu, Q. & Sarkis, J. Diffusion of selected green supply chain management practices : an assessment of chinese enterprises. 2000.

## **DOES ENVIRONMENTAL KNOWLEDGE MODERATE THE RELATIONSHIP BETWEEN HOUSEHOLD DETERMINANTS' INTENTION TO PRACTICE SOLID WASTE SEGREGATION-AT-SOURCE? A CONCEPTUAL PAPER**

K.W. Cheng<sup>1,\*</sup>, S. Osman<sup>1</sup>, Z.M. Jusoh<sup>1</sup> and J.L. Lau<sup>1</sup>

<sup>1</sup>Department of Resource Management and Consumer Studies,  
Faculty of Human Ecology, Universiti Putra Malaysia  
43400 UPM Serdang, Selangor, MALAYSIA

\*Email: gs50840@student.upm.edu.my  
Phone: +60-3-97697094; Fax: +60-3-89435385

### **ABSTRACT**

Previous research has reported that environmental knowledge plays an important role in enhancing general pro-environmental behaviour, as environmental knowledge appears to be the key indicator for increasing awareness of several pollution promulgations and other natural environmental issues. However, the significant role of environmental knowledge in the intention of households to practise solid waste segregation-at-source is not well understood. This research will, therefore, investigate the influence of environmental knowledge on the intention of households to engage in solid waste segregation-at-source. Further analysis will also be carried out to explore the moderating effect of environmental knowledge in the relationship between the households' attitude and subjective norm (i.e. descriptive norm and injunctive norm) with the intention to practise solid waste segregation-at-source. The findings of this current research are expected to provide an essential opportunity to investigate knowledge gaps, to contribute to the enrichment of existing literature, as well as to provide important insights for local households and Malaysian government agencies to strengthen the sense of responsibility for environmental cleanliness.

**Keywords:** Attitude; descriptive norm; injunctive norm; environmental knowledge; intention; solid waste segregation-at-source.

### **INTRODUCTION**

The amount of solid waste generated has always been seen as a global challenge [1]. Waste materials can be categorised according to their different properties, quality, and components. In Malaysia, paper, aluminium, e-waste, plastic, metal, glass, and other recyclables will be first sorted at the point of generation of waste. They are then collected in separate containers, which in turn improve the recycling rate and ensure the efficiency of disposal at household level [2]. Besides that, unscientific and inadequate municipal solid waste practices have led to low environmental quality problems in Malaysia [3-4]. The use of open ground storage or unsightly makeshift containers may impair the city's beautiful image and cause visual pollution [5]. Visual pollution is an aesthetic concern. People who have a high esthetic value in contact with the environment can significantly increase the overall well-being of individuals [6] and vice versa,

since preferences and perceptions of the visual environment are segments of what makes the environment psychologically comfortable.

Generally, as of 30<sup>th</sup> September 2019, there were 142 waste disposal sites under the responsibility of Malaysian local authorities, of which 19 out of 142 solid waste landfill sites were classified as sanitary landfill sites, 119 of which were classified as non-sanitary landfill sites, while the remaining 4 were classified as inert landfill sites. Surprisingly, Sarawak (43) has been recorded as the state with the most non-sanitary landfill sites. It was followed by Sabah (21) and Perak (15) but there are no municipal landfill sites in the Federal Territory of Kuala Lumpur and the Federal Territory of Putrajaya [7]. This current scenario thus drew the attention of local authorities to take serious action to solve the problems of solid waste in this country.

This research aims to explore and fill the gap in existing literature by treating environmental knowledge as a moderating variable between attitude, descriptive norm, injunctive norm, and the intention to practise solid waste segregation-at-source. General research has reported that environmental knowledge plays an important role in improving environmentally friendly behaviour [8] among a group of people. Consumers should therefore be given the opportunity to gain sufficient environmental knowledge through either formal or informal education [9], as environmental knowledge appears to be the key indicator [10] for increasing their awareness of a number of pollution issues and other environmental issues [8]. However, the important role of environmental knowledge in the environmental impact of human industrial production is not well understood [11]. This specific phenomenon tends to cause most people to fail to act in an environmentally responsible manner [12]. This is because they are sensitive enough about the environmental issues that have occurred around them. As a result, many households appeared to underestimate the extent of critical environmental problems [13].

Drawing from the above, the subsequent section outlines the link between the variables studied and the dependent variable, i.e. the intention to practise solid waste segregation-at-source based on the aim of this paper.

## **LITERATURE REVIEW**

### **Intention to Practice Solid Waste Segregation-at-Source**

Current research has used the intention to practise solid waste segregation-at-source as a dependent variable. According to Charuvichaipong and Sajor [14], the intention to practise solid waste segregation-at-source is defined as a tendency to perform a repeat and typical action of separating unwanted material or matter efficiently into different elements according to their recycling potential systematically. More specifically, this is the term used to indicate the extent to which targeted respondents who are likely to carry out waste sorting activities in the required fractions in place of waste products before the disposal process takes place.

In terms of pro-environmental research, taking into account trends in solid waste management in Malaysia, the concept of recycling and solid waste segregation-at-source has only recently been introduced [15]. There is therefore still a lack of useful and relevant information in this specific field of research, particularly in the local context. This situation can be seen from most of the previous research which focusses solely on recycling [16], sustainable development [1, 17-19], and sustainable food products buying intention [20]. In addition to that, despite the implementation and planning of transformative recycling and solid waste segregation-at-source strategies, there are still many challenges to achieving the recycling and solid waste segregation-

at-source objective in order to meet the national recycling target of 22 per cent by 2020 [15]. By realising scarce knowledge and research in this field, this current research provides an essential opportunity to explore the gaps in knowledge and its literature.

### **The Influence of Attitude on Intention to Practice Solid Waste Segregation-at-Source**

Generally, based on Kotler and Amstrong [21] as well as Madden, Ellen, and Ajzen [22], an attitude refers to the degree of unfavourable or favourable appraisal, tendency, evaluation, and feeling of a person with respect to an idea or object. This is due to the Rosenberg [23]'s model of attitude which shows that a person has a negative or positive judgement of an object or idea because of the perceived values that she or he attaches to certain items which, in turn, give rise to her or his cognitive expectations as to the ability of objects or ideas. As a result, the present research predicts that the perceived negative value with respect to the perception of the low value of a product can lead to an unfavourable attitude towards that particular product [24-26] or vice versa. Ideally, if a consumer feels that the value of a product is lower, he or she is likely to have a more unfavourable attitude towards, or generate a lower level of comfort from, that particular product.

Human behavioural intention is closely linked to the level of a person's unfavourable and favourable perception [27]. There is a social dilemma in Australia where there is an environmental attitude problem between green consumers and non-green consumers [28] with regard to their green purchasing intentions. According to Jauhari and Manaktola [29], most people in the National Capital Region of India are likely to return to housing that implements environmental practices due to their positive environmentally friendly experiences, including energy conservation, solid waste reduction-at-source, product-life extension, and pollution prevention. Accordingly, the present research predicts that a more favourable attitude of the household will lead to a higher intention to practise solid waste segregation-at-source.

### **The Relationship between Descriptive Norm and Intention to Practice Solid Waste Segregation-at-Source**

The descriptive norm can be seen as a decision-making shortcut [30] or a social heuristic cue that functions through motivation [31] in a given context. Shealy et al. [31] further explained that heuristics have cognitive elements to attract the attention of decision-makers to their intended behaviour through the norm. Accordingly, the descriptive norm indicates which action is most effective and adaptive in a particular situation [32]. Usually, most people will do whatever the majority of the social group does, because they believe that they can be accepted and approval by a typical, common, and "normal" action. Accordingly, this current research predicts that the intention of households to perform solid waste segregation-at-source is influenced by their common observation of what most others practice in their homes every day. If a household thinks that most of its neighbours are segregating their domestic solid waste, the household is more likely to segregate their domestic solid waste.

In previous environmental and social psychological research, the descriptive norm was applied to the examination of the intention to recycle [33-35], recycling behaviour [36], water conservation [37], littering [32, 38-39], saving energy [40-41], and towel reuse in a hotel setting [41-42]. This section therefore extends the research to provide some useful insights into the relationship between the descriptive norm and other similar areas of research that help academicians to establish a new reference point.

### **The Relationship between Injunctive Norm and Intention to Practice Solid Waste Segregation-at-Source**

The notion of an injunctive norm is based on extrinsic social pressure [43]. This situation is due to the injunctive norm, which always presents the social expectations within one's referent groups or of an important individual, including "people they trust" or "other people who are important to them" [44]. Taken together, in the context of the present research, the researcher can conceptualise the injunctive norm as one of the extrinsic normative factors commonly disapproval or approval for the intention to practise solid waste segregation-at-source among the local households.

Unfortunately, in Czajkowski, Zagorska, and Hanley [45]'s field experiment, they argued that the injunctive norm does not have an impact on the recycling behavioural intention in the Netherlands. Interestingly, Neighbors, O'Connor, Lewis, Chawla, Lee, and Fossos [46] are in the same vein as Czajkowski et al. [45]. In their research on alcohol consumption among 811 American college students, it was shown that the injunctive norm with alcohol drinking behaviour was insignificant. The current researcher therefore predicts that the injunctive norm is a complex concept and that these complexities therefore warrant important and significant consideration in the development of intervention strategies for other socially prohibited behaviours, including, loitering around the city at night, cheating on examinations, stealing from shops, ignoring parental prohibitions, getting drunk, and smoking marijuana.

### **The Relationship between Environmental Knowledge and Intention to Practice Solid Waste Segregation-at-Source**

The current researcher obtains several definitions of environmental knowledge from previous literature published in recent years. For example, Berkes, Folke, and Colding [47] have defined the general environmental knowledge as the cumulative body of a person's knowledge of the independence between the natural environment and human society. This conceptualisation is similar to that of Fryxell and Lo [48], which interpreted the phrase "environmental knowledge" as a type of general knowledge that focusses on the relationship, fact, and concept of the natural environment and the ecosystem. Mostafa [49] further argued that environmental knowledge also includes people's understanding of key relationships that could have consequences for the natural environment. Accordingly, Zsoka, Szerenyi, Szechy, and Kocsis [50] urged people to achieve a certain level of awareness and knowledge on various environmental issues so that possible solutions can be taken immediately to address these current environmental issues and avoid potential future ones [51-53].

Environmental knowledge is one of the psychological factors that has been widely used in existing literature to determine pro-environmental behaviour [54]. However, the explanatory link between environmental knowledge and pro-environmental behaviour has been questioned in the previous literature [13, 55]. More specifically, the link between environmental knowledge and ecological behaviour has been shown to be significant but relatively weak [56]. Due to the circumstances, Paco and Lavrador [57] explained that the increase in knowledge, which merely emphasises the pro-environmental domain, has not always been successfully translated into actual pro-environmental behaviour [58-59], although a large amount of environmental knowledge has increased dramatically over the last decades. As a result, the present researcher suggests that while improving the knowledge of the individual is crucial to increasing the concern for environmental destruction and, in turn, to get to know what actions can be taken to minimise



these consequences, it is much better to let them realise the importance of the natural environment and, subsequently, to engage actively in the conservation and preservation of the environment.

### **The Moderating Effect of Environmental Knowledge on the Relationship between Attitude and Intention to Practice Solid Waste Segregation-at-Source**

To date, there is no existing research that can be verified between attitude, environmental knowledge, and the intention to practise solid waste segregation-at-source. However, positive relationships between these key variables have been successfully recognised in various fields of research [60-63].

In terms of transport mode choices, Flamm [60] looked at the relationship between attitude and environmental knowledge on vehicle ownership and use among 4000 households in Sacramento, which is located in the California metropolitan area. This research has shown that environmental knowledge plays a significant role in shaping the positive environmental attitude of households, which in turn tends to influence their ownership of fuel-efficient vehicles. For example, people with high environmental knowledge of climate change may change their attitudes which, in turn, change their vehicle buying behaviour by purchasing a low emission private car or reducing their car usage in daily routine [64] and therefore consuming less petrol as a non-renewable energy. Meanwhile, another group of researchers [65-66] stressed that households need to understand the causes and consequences of greenhouse gas emissions in order to make them more enjoyable and positive about changing their consumption behaviour towards sustainability, particularly in high-income countries, including Australia, North America, and Europe [67]. Furthermore, with regard to the education and delivery of relevant pro-environmental messages to citizens, Liao [68] carried out a cabin safety education programme for primary school students in Taiwan, which aimed to reveal the 616 students' attitude, knowledge as well as behavioural intention with regards to the cabin safety were positively and significantly enhanced after receiving the relevant safety education. As a result, the current researcher assumes that increasing environmental knowledge will help shape the favourable attitude and enhance the intention of households to practise solid waste segregation-at-source.

### **The Moderating Effect of Environmental Knowledge on the Relationship between Descriptive Norm and Intention to Practice Solid Waste Segregation-at-Source**

Here is the same concern as in the previous section. To the best of the researcher's knowledge, there is no existing literature that focusses primarily on how environmental knowledge influences the descriptive norm towards the intention to practise solid waste segregation-at-source. It remains unclear, therefore, whether the descriptive norm towards environmental knowledge is related to Selangor households' intention to practise solid waste segregation-at-source. This current research was thus intended to explore this unknown idea by discovering the interrelationships between the variables studied.

It is interesting to note that there is a common assumption that the majority of people are not willing to be consciously frustrated about the natural environment and therefore to take intentional pro-environmentally action [69-70]. As such, Frick et al. [56] argued that environmental knowledge was commonly emphasised as a prerequisite for volitional action. This situation shows that, although environmental knowledge has somehow been perceived as a necessary factor, it is simply not enough to influence a group of people to act in a pro-environmental manner [13].

Meanwhile, past empirical research has shown that the descriptive norm has a significant influence on people's important referents to conduct "appropriate" behaviour within a specific environmental [43]. It also perceived the importance of nature-based environmental education, which involves the learning process of environmental knowledge with the introduction of an intrinsic factor, namely descriptive norm, to act as a holistic method to enhance the ecological behaviour of the nation [59]. Accordingly, the present researcher takes this idea further, suggesting that the moderating effect of environmental knowledge has a significant and positive impact on the relationship between the descriptive norm and the intention to practise solid waste segregation-at-source.

### **The Moderating Effect of Environmental Knowledge on the Relationship between Injunctive Norm and Intention to Practice Solid Waste Segregation-at-Source**

Environmental knowledge is theorised to have both an indirect and a direct effect on the general pro-environmental behaviour of the respondents [71-73]. Previous researchers in the field of environmental psychology have urged future research to focus on specific pro-environmental activities instead of aggregated variables to predict individuals' general eco-friendly behaviours [74-75]. Unfortunately, the role of environmental knowledge as a moderator on the link between the injunctive norm and the intention to practise solid waste segregation-at-source has not yet been discussed in any previous research. As a result, this current research projected to broaden the researchers' understanding of the specific interrelationships between these studied variables.

The essence of environmental knowledge relies heavily on nature-based environmental education provided by institutions that emphasise the introduction of environmental knowledge in respect of the ecosystem, fauna, and flora through a physical link with the environment [59]. Furthermore, the present researcher assumes that the generalisation of environmental knowledge within the local community is a prerequisite for ensuring that certain pro-environmental policies are accepted and effectively implemented. The participation rate among the local community is vital to be considered in the context of national environmental management and policy [76]. This situation highlights the importance of sharing relevant environmental knowledge among members of the local community in order to provide broad support for public decisions [77]. Following this line of reasoning, in order to gain a sense of belonging and avoid sanctions, the local community will see the commonly practised behaviour as a socially approved decision, as it produces a certain amount of social pressure recognised by the other members of the community. Accordingly, in the context of this current research, the present research suggests that effective and appropriate communication tools should be developed to convey relevant messages to encourage residents to perform the solid waste segregation-at-source and to catalyse their concerns about the importance of protecting the finite natural environment.

## **CONCLUSIONS**

This current research was designed to further exploring the interrelationships between attitude, descriptive norm, injunctive norm, environmental knowledge, and the intention to practise solid waste segregation-at-source. The availability of existing literature of the studied variables in the context of current research scope are limited and rare. Hence, the present research

provides a significant platform to investigate knowledge gaps which in turn to contribute to the enrichment of existing literature. As a result, the present research is expected to provide important insights for general interests, including local households and Malaysian government agencies to strengthen the sense of responsibility for environmental cleanliness.

This current research could develop a medium for households to learn more about the policy of solid waste segregation by receiving relative information through this research. It is very important that the citizen is empowered be a knowledgeable citizen, especially with regard to the correct and systematic handling and management of their daily domestic solid waste [78]. The researcher expects that they will therefore be able to further improve their capabilities, which, in turn, will enable them to protect the natural environment for the sake of current and future generations.

Last but not least, current research could be valuable for Malaysian governmental agencies to develop a favourable policy implementation framework to address recent solid waste issues in the country. The current researcher expects respondents to feel motivated to cultivate their intention to practise solid waste segregation-at-source if they are given some gifts and rewards. As a result, current research could provide guidance to the relevant Malaysian governmental bodies, in particular the National Solid Waste Management Department, Solid Waste Management and Public Cleansing Corporation, Malaysian Ministry of Energy, Science, Technology, Environment and Climate Change, and Malaysian Ministry of Housing and Local Government, to consider this circumstance in their future policy implementation.

## ACKNOWLEDGEMENTS

The authors would like to thank all government agencies, research officers, and any other parties involved in the research.

## REFERENCES

- [1] Otitoju, T. A. & Seng, L. (2014). Municipal solid waste management: Household waste segregation in Kuching South City, Sarawak, Malaysia. *American Journal of Engineering Research (AJER)*, 3(6), 82-91.
- [2] Priyadarshini, P. & Abhilash, P. C. (2020). Circular economy practices within energy and waste management sectors of India: A meta-analysis. *Bioresource Technology*, 304, 123018.
- [3] Khajuria, A., Yamamoto, Y., & Morioka, T. (2010). Estimation of municipal solid waste generation and landfill area in Asian developing countries. *Journal of Environmental Biology*, 31(5), 649-654.
- [4] Nadi, B., Shamshiry, E., & Mahmud, A. R. (2011). Response Surfaces Model for Optimisation of Solid Waste Management. *International Journal of Chemical Engineering and Applications*, 2(1), 12-13.
- [5] Chung, D. Y. L., Muda, A., Omar, C. M. C., & Manaf, L. A. (2016). Residents' perceptions of the visual quality of on-site waste storage bins in Kuching. *Asian Journal of Environment-Behaviour Studies*, 1(1), 87-98.

- [6] Tweed, C. & Sutherland, M. (2007). Built cultural heritage and sustainable urban development. *Landscape and Urban Planning*, 83(1), 62-69.
- [7] Ministry of Housing and Local Government. (2015). Separation-at-Source. Retrieved on February 23<sup>rd</sup>, 2020 from <https://www.kpkt.gov.my/separationatsource/en/>
- [8] Tong, Q., Anders, S., Zhang, J., & Zhang, L. (2020). The roles of pollution concerns and environmental knowledge in making green food choices: Evidence from Chinese consumers. *Food Research International*, 130, 108881.
- [9] Hunter, A. B., Laursen, S. L., & Seymour, E. (2007). Becoming a scientist: The role of undergraduate research in students' cognitive, personal, and professional development. *Science Education*, 91(1), 36-74.
- [10] Safari, A., Salehzadeh, R., Panahi, R., & Abolghasemian, S. (2018). Multiple pathways linking environmental knowledge and awareness to employees' green behaviour. *Corporate Governance: The International Journal of Business in Society*, 18(1), 81-103.
- [11] Alexy, P., Anklam, E., Emans, T., Furfari, A., Galgani, F., Hanke, G., ... & Sokull Kluettgen, B. (2020). Managing the analytical challenges related to micro-and nanoplastics in the environment and food: Filling the knowledge gaps. *Food Additives and Contaminants: Part A*, 37(1), 1-10.
- [12] Grob, A. (1995). A structural model of environmental attitudes and behaviour. *Journal of Environmental Psychology*, 15(3), 209-220.
- [13] Kollmuss, A. & Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behaviour?. *Environmental Education Research*, 8(3), 239-260.
- [14] Charuvichaipong, C. & Sajor, E. (2006). Promoting waste separation for recycling and local governance in Thailand. *Habitat International*, 30(3), 579-594.
- [15] Moh, Y. C. & Manaf, L. A. (2014). Overview of household solid waste recycling policy status and challenges in Malaysia. *Resources, Conservation and Recycling*, 82, 50-61.
- [16] Tiew, K. G., Basri, N. E. A., Watanabe, K., Zain, S. M., Er, A. C., & Deng, H. (2019). Higher educational institutions recycling management in Malaysia. *International Journal of Business and Society*, 20(1), 277-285.
- [17] Macovei, O. I. (2015). Applying the theory of planned behaviour in predicting pro-environmental behaviour: The case of energy conservation. *Acta Universitatis Danubius. Œconomica*, 11(4), 15-32.
- [18] Musa, H. D., Yacob, M. R., & Abdullah, A. M. (2019). Delphi exploration of subjective well-being indicators for strategic urban planning towards sustainable development in Malaysia. *Journal of Urban Management*, 8(1), 28-41.
- [19] Wan, C. & Shen, G. Q. (2015). Encouraging the use of urban green space: The mediating role of attitude, perceived usefulness and perceived behavioural control. *Habitat International*, 50, 130-139.
- [20] Yogananda, A. P. Y. & Nair, P. B. (2019). Green Food Product Purchase Intention: Factors Influencing Malaysian Consumers. *Pertanika Journal of Social Sciences and Humanities*, 27(2), 1131-1144.
- [21] Kotler, P. & Amstrong, G. (2013). *Fundamentals of Marketing*. Mexico City: Mexico: Pearson Prentice Hall.

- [22] Madden, T. J., Ellen, P. S., & Ajzen, I. (1992). A comparison of the theory of planned behaviour and the theory of reasoned action. *Personality and Social Psychology Bulletin*, 18(1), 3-9.
- [23] Rosenberg, M. J. (1956). Cognitive structure and attitudinal affect. *The Journal of Abnormal and Social Psychology*, 53(3), 367.
- [24] Almasi, A., Mohammadi, M., Azizi, A., Berizi, Z., Shamsi, K., Shahbazi, A., & Mosavi, S. A. (2019). Assessing the knowledge, attitude and practice of the kermanshahi women towards reducing, recycling and reusing of municipal solid waste. *Resources, Conservation and Recycling*, 141, 329-338.
- [25] Hwang, J. & Hyun, S. S. (2017). First-class airline travellers' tendency to seek uniqueness: How does it influence their purchase of expensive tickets?. *Journal of Travel and Tourism Marketing*, 34(7), 935-947.
- [26] Lyu, S. O. & Hwang, J. (2017). Saving golf courses from business troubles. *Journal of Travel & Tourism Marketing*, 34(8), 1089-1100.
- [27] Jitrumluek, P., Falcioni, R., Thiengkamol, N., & Thiengkamol, T. K. (2019). Entrepreneur's pro-environmental behaviour: The mediating role of corporate social responsibility. *The Journal of Behavioural Science*, 14(1), 14-27.
- [28] Gupta, S. & Ogden, D. T. (2009). To buy or not to buy? A social dilemma perspective on green buying. *Journal of Consumer Marketing*, 26(6), 376-391.
- [29] Jauhari, V. & Manaktola, K. (2007). Exploring consumer attitude and behaviour towards green practices in the lodging industry in India. *International Journal of Contemporary Hospitality Management*, 19(5), 364-377.
- [30] Lapinski, M. K., Zhuang, J., Koh, H., & Shi, J. (2017). Descriptive norms and involvement in health and environmental behaviours. *Communication Research*, 44(3), 367-387.
- [31] Shealy, T., Johnson, E., Weber, E., Klotz, L., Applegate, S., Ismael, D., & Bell, R. G. (2018). Providing descriptive norms during engineering design can encourage more sustainable infrastructure. *Sustainable Cities and Society*, 40, 182-188.
- [32] Cialdini, R. B., Reno, R. R., & Kallgren, C. A. (1990). A focus theory of normative conduct: Recycling the concept of norms to reduce littering in public places. *Journal of Personality and Social Psychology*, 58(6), 1015-1026.
- [33] Geiger, J. L., Steg, L., van der Werff, E., & Unal, A. B. (2019). A meta-analysis of factors related to recycling. *Journal of Environmental Psychology*, 64, 78-97.
- [34] Nigbur, D., Lyons, E., & Uzzell, D. (2010). Attitudes, norms, identity and environmental behaviour: Using an expanded theory of planned behaviour to predict participation in a kerbside recycling programme. *British Journal of Social Psychology*, 49(2), 259-284.
- [35] Viscusi, W. K., Huber, J., & Bell, J. (2014). Private recycling values, social norms, and legal rules. *Revue D'économie Politique*, 124(2), 159-178.
- [36] Schultz, P. W. (1999). Changing behaviour with normative feedback interventions: A field experiment on curbside recycling. *Basic and Applied Social Psychology*, 21(1), 25-36.
- [37] Schultz, P. W., Khazian, M. A., & Zaleski, C. A. (2008). Using normative social influence to promote conservation among hotel guests. *Social Influence*, 3(1), 4-23.
- [38] Kallgren, C. A., Reno, R. R., & Cialdini, R. B. (2000). A focus theory of normative conduct: When norms do and do not affect behaviour. *Personality and Social Psychology Bulletin*, 26(8), 1002-1012.

- [39] Reno, R. R., Cialdini, R. B., & Kallgren, C. A. (1993). The trans situational influence of social norms. *Journal of Personality and Social Psychology*, 64(1), 104.
- [40] Cialdini, R. B. (2003). Crafting normative messages to protect the environment. *Current Directions in Psychological Science*, 12(4), 105-109.
- [41] Goldstein, N. J., Cialdini, R. B., & Griskevicius, V. (2008). A room with a viewpoint: Using social norms to motivate environmental conservation in hotels. *Journal of Consumer Research*, 35(3), 472-482.
- [42] Reese, G., Loew, K., & Steffgen, G. (2014). A towel less: Social norms enhance pro-environmental behaviour in hotels. *The Journal of Social Psychology*, 154(2), 97-100.
- [43] Wang, S., Fan, J., Zhao, D., Yang, S., & Fu, Y. (2016). Predicting consumers' intention to adopt hybrid electric vehicles: Using an extended version of the theory of planned behaviour model. *Transportation*, 43(1), 123-143.
- [44] Cestac, J., Paran, F., & Delhomme, P. (2014). Drive as I say, not as I drive: Influence of injunctive and descriptive norms on speeding intentions among young drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, 23, 44-56.
- [45] Czajkowski, M., Zagorska, K., & Hanley, N. (2019). Social norm nudging and preferences for household recycling. *Resource and Energy Economics*, 58, 101110.
- [46] Neighbors, C., O'Connor, R. M., Lewis, M. A., Chawla, N., Lee, C. M., & Fossos, N. (2008). The relative impact of injunctive norms on college student drinking: The role of reference group. *Psychology of Addictive Behaviours*, 22(4), 576.
- [47] Berkes, F., Colding, J., & Folke, C. (2000). Rediscovery of traditional ecological knowledge as adaptive management. *Ecological Applications*, 10(5), 1251-1262.
- [48] Fryxell, G. E. & Lo, C. W. (2003). The influence of environmental knowledge and values on managerial behaviours on behalf of the environment: An empirical examination of managers in China. *Journal of Business Ethics*, 46(1), 45-69.
- [49] Mostafa, M. M. (2007). A hierarchical analysis of the green consciousness of the Egyptian consumer. *Psychology and Marketing*, 24(5), 445-473.
- [50] Zsoka, A., Szerenyi, Z. M., Szechy, A., & Kocsis, T. (2013). Greening due to environmental education? Environmental knowledge, attitudes, consumer behaviour and everyday pro-environmental activities of Hungarian high school and university students. *Journal of Cleaner Production*, 48, 126-138.
- [51] Kim, M. (2011). Science, technology and the environment: the views of urban children and implications for science and environmental education in Korea. *Environmental Education Research*, 17(2), 261-280.
- [52] Moseley, C. (2000). Teaching for environmental literacy. *The Clearing House*, 74(1), 23-24.
- [53] Sheth, J. N., Sethia, N. K., & Srinivas, S. (2011). Mindful consumption: A customer-centric approach to sustainability. *Journal of the Academy of Marketing Science*, 39(1), 21-39.
- [54] Casalo, L. V., Escario, J. J., & Rodriguez-Sanchez, C. (2019). Analysing differences between different types of pro-environmental behaviours: Do attitude intensity and type of knowledge matter?. *Resources, Conservation and Recycling*, 149, 56-64.
- [55] Bamberg, S. & Moser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, 27(1), 14-25.

- [56] Frick, J., Kaiser, F. G., & Wilson, M. (2004). Environmental knowledge and conservation behaviour: Exploring prevalence and structure in a representative sample. *Personality and Individual Differences*, 37(8), 1597-1613.
- [57] Paco, A. & Lavrador, T. (2017). Environmental knowledge and attitudes and behaviours towards energy consumption. *Journal of Environmental Management*, 197, 384-392.
- [58] Abrahamse, W., Steg, L., Vlek, C., & Rothengatter, T. (2005). A review of intervention studies aimed at household energy conservation. *Journal of Environmental Psychology*, 25(3), 273-291.
- [59] Otto, S. & Pensini, P. (2017). Nature-based environmental education of children: Environmental knowledge and connectedness to nature, together, are related to ecological behaviour. *Global Environmental Change*, 47, 88-94.
- [60] Flamm, B. (2009). The impacts of environmental knowledge and attitudes on vehicle ownership and use. *Transportation Research Part D: Transport and Environment*, 14(4), 272-279.
- [61] Kim, Y., Yun, S., & Lee, J. (2014). Can companies induce sustainable consumption? The impact of knowledge and social embeddedness on airline sustainability programs in the US. *Sustainability*, 6(6), 3338-3356.
- [62] Lera-Lopez, F., Sanchez, M., Faulin, J., & Cacciolatti, L. (2014). Rural environment stakeholders and policy making: Willingness to pay to reduce road transportation pollution impact in the Western Pyrenees. *Transportation Research Part D: Transport and Environment*, 32, 129-142.
- [63] Nilsson, M. & Kuller, R. (2000). Travel behaviour and environmental concern. *Transportation Research Part D: Transport and Environment*, 5(3), 211-234.
- [64] Heimlich, J. E. & Ardoin, N. M. (2008). Understanding behaviour to understand behaviour change: A literature review. *Environmental Education Research*, 14(3), 215-237.
- [65] Dubois, G., Sovacool, B., Aall, C., Nilsson, M., Barbier, C., Herrmann, A., ... & Dorner, F. (2019). It starts at home? Climate policies targeting household consumption and behavioral decisions are key to low-carbon futures. *Energy Research and Social Science*, 52, 144-158.
- [66] O'Connor, R. E., Bord, R. J., Yarnal, B., & Wiefek, N. (2002). Who wants to reduce greenhouse gas emissions?. *Social Science Quarterly*, 83(1), 1-17.
- [67] Sanne, C. (2002). Willing consumers—or locked-in? Policies for a sustainable consumption. *Ecological Economics*, 42(1-2), 273-287.
- [68] Liao, M. Y. (2014). An evaluation of an airline cabin safety education program for elementary school children. *Evaluation and Program Planning*, 43, 27-37.
- [69] Gifford, R. & Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology*, 49(3), 141-157.
- [70] Meinhold, J. L. & Malkus, A. J. (2005). Adolescent environmental behaviours: Can knowledge, attitudes, and self-efficacy make a difference?. *Environment and Behaviour*, 37(4), 511-532.
- [71] Botetzagias, I., Dima, A. F., & Malesios, C. (2015). Extending the theory of planned behaviour in the context of recycling: The role of moral norms and of demographic predictors. *Resources, Conservation and Recycling*, 95, 58-67.
- [72] Kitzmuller, C. (2009). *Environmental Knowledge and Willingness to Change Personal Behaviour: An American-Austrian Comparison of Energy Use*. Retrieved on January 21<sup>st</sup>, 2020

- from <https://www.uni-muenster.de/imperia/md/content/transpose/publikationen/kitzmueller.pdf>
- [73] Lu, J. L. & Wang, C. Y. (2018). Investigating the impacts of air travellers' environmental knowledge on attitudes toward carbon offsetting and willingness to mitigate the environmental impacts of aviation. *Transportation Research Part D: Transport and Environment*, 59, 96-107.
- [74] Gatersleben, B., Murtagh, N., & Abrahamse, W. (2014). Values, identity and pro-environmental behaviour. *Contemporary Social Science*, 9(4), 374-392.
- [75] Karlin, B., Davis, N., Sanguinetti, A., Gamble, K., Kirkby, D., & Stokols, D. (2014). Dimensions of conservation: Exploring differences among energy behaviours. *Environment and Behaviour*, 46(4), 423-452.
- [76] Benham, C. F. (2017). Aligning public participation with local environmental knowledge in complex marine social-ecological systems. *Marine Policy*, 82, 16-24.
- [77] Reed, M. S. (2008). Stakeholder participation for environmental management: A literature review. *Biological Conservation*, 141(10), 2417-2431.
- [78] Manggali, A. A. & Susanna, D. (2019). Current management of household hazardous waste (HHW) in the Asian region. *Reviews on Environmental Health*, 34(4), 415-426.



